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THE Psychological Monographs

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I

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THE Psychological Monographs

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ON THE FUNCTIONS OF THE CEREBRUM

I

Symptomatological Differences Associated with Similar Cerebral Lesions in the Insane

By

SHEPHERD IVORY FRANZ

II

Variations in Distribution of the Motor Centers

By

SHEPHERD IVORY FRANZ

With the Assistance of

J. DUERSON STOUT

PSYCHOLOGICAL REVIEW COMPANY

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PRINCETON
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PRESS

PREFACE

The two articles which constitute the present monograph deal with the same general topic, the variations in function of corresponding parts of different brains. This matter has received scant attention in neurological literature, notwithstanding the fact that the anatomical variations have been extensively studied. The data recorded in the two articles point to a conclusion which helps to an understanding and to a conciliation of some apparent discrepancies in previous clinical and experimental studies of cerebral function. The theoretical discussion which is given is, however, not due solely to the work now presented, but in great part has been the result of previous personal observations and of various facts which have been recounted in clinico—and physiological—neurological literature.

The experimental data of the second article were collected before the examination of the clinico-pathological data contained in the first article was begun. Many results of the experimental study could not be prepared for publication in the present article, and a number of duties prevented the earlier completion of the article as it now stands, but it is hoped that time will be found for the early presentation of the other collected facts which bear upon the same problem. Part of the first study was prepared for, but was not presented at, the conference on individual differences at Columbia University in celebration of the twenty-fifth anniversary of the professorship of J. McKeen Cattell.

In the experimental part of the present work the author has had the assistance of and is under obligation to a number of former students, and of internes at the Government Hospital for the Insane, too numerous to mention separately. The major part of the assistance was given by Dr. J. Duerson Stout, now associate professor of physiology and pharmacology in the George Washington University and his name appears, therefore, on the title page.

PREFACE

The research on the brains of the monkeys was made possible by reason of a grant to the author, for the purchase and maintenance of animals for the investigation of the functions of the cerebrum, by the Carnegie Institution of Washington, and for making possible this and other similar previous investigations the author here expresses his sense of obligation.

For the convenience of the reader it may be mentioned that summaries of the experimental work appear at the ends of the individual sections of that article (see pp. 102, 105, 132, and 139).

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I

SYMPTOMATOLOGICAL DIFFERENCES ASSOCIATED WITH SIMILAR CEREBRAL LESIONS IN THE INSANE

INTRODUCTION

It is well known that in different diseases similar symptoms are often exhibited. For example, anemia and fever are not more characteristic of one special disease than of a multitude of others. On the other hand, discomfort and malaise are so constantly reported by those who are sick, that they can not be said to be of more than minor diagnostic value. Even pains are so commonly concomitants of different diseases that, except when definitely localized, and not always then, they almost cease to be of diagnostic or prognostic importance. In the mental disease, the individual symptom is often less valuable, if this be possible, as an indication of the special disease. A depression or a sadness, an hallucination or a delusion, defects of retention or of comprehension, and evidences of loose thinking and the like are elements or symptoms in many of the psychoses. Not one is pathognomonic of a special disease, each is an expression of a physiological conflict or of a loss or defect of anatomical, and also functional, cerebral elements.

Although no one symptom or condition can be relied upon for the purpose of diagnosis, the combination of symptoms does give most often plain evidence of the nature of the special disorder. The recognition of the fact that diagnostic reliance may be placed upon the collection or concatenation of symptoms has led to the foundation and the elaboration of a system of knowledge, we might almost say a science, which is called differential diagnostics. The development of this field has also been due to the realization that in the same disease in different individuals the micro-organisms may produce different effects, or the body physiologically

may be affected differently, and there may result different prominent systems in different individuals. Apart from the so-called mildness or the severity of the disease, one individual may exhibit high temperature, another may exhibit a temperature only slightly above the normal. In one individual the diseased condition of one of the heart valves may exist for many years without obvious symptoms which attract the patient's attention because of compensation in both the strength and the size of the heart, while a similar pathological state in another patient gives rise to distress, sharp pains and faintness.

These similarities of symptoms in different diseases and the variations in symptoms in different individuals with the same disease are paralleled by variations in actions of different drugs and by differences in the reactions of different individuals to some foods. In some, the eating of strawberries or of fish is accompanied by disagreeable effects, and in other individuals the effects following the administration of therapeutic doses of certain drugs are not only disagreeable but often dangerous. Small amounts of the derivatives of opium, of arsenic, of antipyrine, and of even generally supposed-to-be-harmless quinine at times give rise to violent physiological reaction, although most people may take small doses of these drugs with impunity and without apparent physiological changes.

In the older psychiatry individual symptoms or concomitant physical conditions were uncritically believed to have major importance and, because of this, dissimilar diseases were considered to be the same. When certain etiological factors were determined and when the symptomatological variations were carefully considered it became apparent that superficially different groupings of symptoms might be and often are essentially similar. Notwithstanding these supposedly fundamental similarities as we see them at present, there remain many prominent points of differences in the symptoms in individuals who suffer from the same disease. These individual differences have been supposed to be due to or to be connected with variations in the normal mental make-up of the patient, or to variations in lesions or in functional disturbances of cerebral centers or connections.

To account for the individual variations in both mental and nervous diseases, the psychoses and the neuroses, it has been most easy and quite satisfying to presuppose functional and structional differences of the lesions, because of our relative ignorance of many of the functions and of the anatomical connections of parts of the nervous system. This is specially true when we deal with lesions or disease of the cerebrum and the basal ganglia. Within recent years, however, there has been growing the realization that a minute lesion in one part of the brain may give rise to a symptom or to a collection of symptoms which is exactly the same as that resulting from a similarly minute lesion in a second or a third portion of that organ. If we liken the cerebral mechanism to the stations and lines of a telephone or a telegraph plant we may readily understand how this can be. If the emissive element or the transmitter be broken or destroyed it is not possible to transmit the message in a particular direction or to a given point. The function is abolished. But we must also keep in mind that a similar abnormal condition of function arises if, instead of having a lesion of the emissive element, there be a break in any part of the conducting line. Such an injury or a disease may be close to or far from the transmitter and may even be in the receiver.

Lesions in the nervous system minute enough to embrace an individual nerve cell or its processes are never found. The smallest always involve many elements. But even though this be true, it has been shown that such lesions in different parts may result in similar physiological disturbances. Lesions of such widely separated parts of the nervous system as the frontal lobes and the cerebellum are known to produce similar symptoms, and in many cases a definite diagnosis can be made only after death. Usually, however, concurrent with the main, or with the more prominent, symptoms other symptoms are found. These additional symptoms point to disturbances of structures anatomically allied to the one which is chiefly involved or which is entirely destroyed, and they permit fairly accurate neurological diagnostic localizations in many cases during life. Thus, for

example, we find it possible to predict the localizations of lesions in individuals with paralyses because of the association of several paralyzed segments, or because of concomitant sensibility disorders.

The reverse state of affairs is seldom considered. Is it, we may ask, possible that anatomically similar lesions of the cerebrum give rise to dissimilar symptoms in different individuals? The consequences of a positive or a negative answer to this question are of great importance. If similar cerebral lesions do not always produce similar symptoms, there is opened a series of problems regarding the "why" and the "how" of cerebral function which are fundamental. If similar cerebral lesions are always accompanied by similar mental changes, our conceptions of cerebral mechanics may remain simple and our explanations of the relations of mental and cerebral functions become less difficult.

Because of these considerations it appeared desirable to make a special study of possible differences in symptoms accompanying similar cerebral lesions. For this purpose there were available autopsy and clinical records of nearly 3,300 patients who had been in the Government Hospital for the Insane. The clinical records of many were so meagre that attempted correlations of the cerebral lesions with the clinical symptoms would, in these cases, have been futile, and it appeared would have resulted in a loss of time. For this reason only those cases have been considered in which there were recorded the results of fairly complete mental examinations as well as the autopsy examinations. These considerations resulted in the primary rejections of all but the last 950 autopsy cases, representing roughly those autopsies which had been performed during the past six or seven years. It was also found that about one-third of these must also be rejected on account of insufficient clinical examinations, and because of indefinite diagnostic data. The cases which were eventually selected were of all kinds of mental diseases, but the series is particularly strong in the organic psychoses, such as paresis, arteriosclerotic dementia, senile dementia, and the like.

The brains of these individuals showed a great variety of lesions, inflammatory, atrophic, hemorrhagic, and the like. These were divided into two general groups, one in which there was a single or unitary lesion, the other in which there was a combination of cerebral lesions. Those in which there were two kinds of lesions, *e. g.,* softening and atrophy, were excluded. The cases which showed atrophy were the most numerous and these were selected for the present study. These were separated into two general classes: (1) Those in which the atrophy was general but in which there might be a greater atrophic condition in one portion of the cerebrum, and (2) those in which the atrophy was well localized in one special region of the cerebral cortex. The second group is the one which has been more carefully studied at the present time. From this group, as has been stated above, there have been omitted almost all those cases in which there were other gross lesions of parts of the cerebrum or of the nervous system in general. A few cases in which the only additional lesions were recent cerebral hemorrhages, that resulted in the death of the patients, were included, because whatever mental changes had been observed during the major part of their hospital residence could not have been due to these lesions. It might also have been possible to include certain cases in which localized softenings accompanied the atrophy, because in a number of cases these additional pathological conditions were due to comparatively recent cerebral insults. Since, however, definite dates could not be assigned to some of them, they have been excluded from the present report.

The atrophies which are dealt with here are those which, as defined by Blackburn[1], imply "reduction in size and weight of an organ which has been at one time of greater volume and weight, though the organ may not have been orginally up to the normal standard. It also implies that this atrophy is the result of degeneration and diminution of the elements of the tissue and not merely the result of pressure or gross loss of substance." In old age this condition of atrophy of the cerebrum is met with as

[1] Blackburn, I. W. Atrophy of the Brain in the Insane. *Govt. Hosp. for the Insane Bull.,* 1911, 3, 45-50.

a common concomitant of the general bodily degenerative changes, and it may be due solely to these degenerative tendencies of the body as a whole. The condition of cerebral atrophy is also to be found in a variety of other mental diseases besides that of senile dementia, and it is particularly noticeable in many cases of general paralysis of the insane. The atrophies may, it has been shown, be primary, *i.e.,* due to degenerations of the cells, without concomitant changes in the blood vessels, or they may be the result of partial blocking of or difficulties in the course of the blood flow. The atrophies which accompany cerebral arteriosclerosis are allied, some think, to the atrophies which are found in general paralysis of the insane, in that they are atrophies of a secondary nature, whereas the atrophies which are found in senile dementia, and possibly also in dementia precox, are more frequently primary atrophies. In many cases the atrophies are so distributed that it is apparent they do not depend upon changes in the arterial supply. In fact, in many instances the gross and also the histological examinations may fail to show any sclerotic changes in the blood vessels. In this connection, it may be noted that Blackburn has pointed out that in certain cases there may be a complete preservation of certain cortical areas with an atrophy of surrounding or neighboring zones which are supplied by the same vessel.

In many cases the cerebral atrophy is general, but regional atrophies are frequently met with, such as those of the frontal, or parietal or temporal lobes. In paresis it is not uncommon to find such localized atrophies, and these are more frequent in the frontal lobes. There is, however, an atrophy of the parietal region, circumscribed in character, which has been described by Lissauer. Although the symptoms due to this circumscribed atrophic condition of the posterior half of the brain include certain focal manifestations, especially those of disturbances in speech of the nature of the aphasias, the other symptoms do not differ very markedly from the symptoms accompanying more generalized or frontal atrophy, and previous to death it is not usually possible to diganose this condition. Kraepelin[2] reports

[2] Kraepelin, E., General Paresis (trans. by I. W. Moore). Nerv. and Ment. Dis. Monog. No. 14. Pp. v + 200. (See especially pp. 134-135.)

that in this Lissauer type of paresis the course of the disease is spasmodic and resembles, to some extent, cortical epilepsy, while the deterioration is more gradual than in the frontal atrophies. This type of case is estimated by Alzheimer to comprise about 15 per cent of the total cases of paresis. Similar circumscribed, or regional, atrophies are also found in cases of senile dementia, arteriosclerotic dementia, and dementia precox.

In regard to the relation of atrophies to the clinical symptoms Blackburn has written: "The conclusions reached by long experience are that in all cases of insanity of long standing in which there is a demonstrable mental deterioration we may confidently predict that some shrinkage of the brain may be found; that as a rule the degree of dementia is commensurate with the atrophy found or present; and that the localization of this shrinkage in the prefrontal region in most cases is a strong presumptive evidence of the seat of intellectual processes in that part of the brain."[3] He furthermore states that the fact that the secondary degenerative atrophy "is confined most frequently to the frontal lobes and the prefrontal region is strikingly significant in view of the supposed intellectual function of these parts." On the other hand, it should be mentioned that senile dementia may be evident without concomitant atrophic conditions in the brain. This is also true for dementia precox, and whatever relations the atrophic conditions bear to the changes in mental characters which are grouped together under the general term "mental deterioration" are at present unknown. Since deterioration may exist without obvious atrophy it is apparent that the atrophy, in itself, is not necessary for the production of the symptoms. That, however, the symptoms do, in many cases at least, depend upon the cerebral changes we may believe. The relation, direct or indirect, of the cerebral lesions with the symptoms has not yet been sufficiently shown.

After the elimination of the cases with multiple lesions a total of sixty cases was obtained with sufficiently complete clinical and pathological histories to make certain comparisons of value. Some of these were not usable in the present study on account

[3] *Op. cit.*

of the fact that they were diagnostically doubtful cases or there were too few cases of the special kind of mental disease to make valuable symptom-lesion correlations. In general it was believed that at least four or more cases of a particular psychosis were needed if the individual differences and similarities were to be dealt with properly, and on account of this twenty-two cases were omitted from the present work. The omitted cases were: manic-depressive and allied psychoses, 7; intoxication psychoses, 2; imbecility, 1; epilepsy with dementia, 1; paralysis agitans, 1; cerebral syphilis, 3; organic diseases of the brain not otherwise differentiated, 3; undiagnosed or unclassified psychoses, 4. The remaining thirty-eight cases were distributed as follows: dementia precox, 9; general paralysis of the insane, 6; arteriosclerotic dementia, 9; senile dementia, 14. Thirteen of these cases were described in the autopsy records as simple frontal atrophies; two were cases in which the brain was generally atrophied but the atrophies of the frontal regions were great; eighteen cases were described as anterior atrophies, and by this is meant that the regions anterior to the central fissure (including, therefore, the so-called motor region in addition to the frontal area) were atrophied; four cases showed atrophy over the anterior two-thirds of the cerebrum, including therefore more of the cortex than in the cases previously mentioned; one additional case, in which the atrophy covered the frontal region and the posterior portion of the parietal area, was included for comparison. The distribution of these extents of atrophies in the different diseases is given in the accompanying table and comparisons are also made in the discussions.

Mental Diseases	Characters of atrophy					
	Frontal	Frontal and general	Anterior	Anterior two-thirds	Frontal and posterior parietal	Totals
Dementia precox	3	0	5	1	0	9
General paralysis of the insane	3	0	3	0	0	6
Arteriosclerotic dementia	2	2	5	0	0	9
Senile dementia	5	0	5	3	1	14
Totals	13	2	18	4	1	38

DEMENTIA PRECOX, CLINICAL HISTORIES

Case 1, white female, was admitted to the Hospital at the age of 54 and lived for 3 years and 6 months.

Her family history was bad; her father was nervous, her maternal cousin was insane, and her mother was an invalid for a number of years before her death, which was due to ovarian tumor; the patient attended private schools until the age of seventeen; she was considered to be sickly all her life; for many years she showed marked peculiarities of conduct, was contrary, and had spells of high temper at intervals varying from a week to several months; at one time she lived in an eighteen-room house with only a dog for company for a period of fifteen years. The mental disorder which led to her commitment was probably of very long standing, but the occasion of commitment was the manifestation of delusions of persecution by "witches" and by the "Black Hand Society"; she was also extremely nervous, had insomia, refused to eat, and exhibited homicidal tendencies. She would not permit either physical or neurological examination, but exhibited no obvious physical or neurological abnormalities except a few small sores over trunk and limbs. She was restless, suspicious of almost every one about her; she refused to talk freely about herself; at times she imagined the food was poisoned and refused to take it on this account, but on being assured that there was no poison or after it had been tasted by another, she would take it; she also feared that the towels, the combs, the water, etc., contained poison; she had hallucinations of hearing (she had heard her mother's and brother's voices talking to her) and also of skin sensations (she said that she was electrical and could give out power at any time; she also reported that electric currents had been turned upon her for years by her enemies); she believed that she was especially favored by the Lord and that she received signs of this; her memory was excellent and when she was persuaded to talk, she gave detailed accounts of her past and of the conditions which led up to the persecutions to which she believed she had been subjected; her attention did not appear to be

impaired, and there was no distractability; she had no appreciation of her mental condition; she was well oriented in all spheres; there was no clouding of consciousness; she reported (incorrectly) that she did not sleep well; and she answered incoherently at most times. Later she became indifferent, but at times was noted to be emotionally labile; she was irresponsible; her answers were circumstantial, irrelevant, or incoherent; at times she was disturbed, noisy, destructive, violent, and untidy; she wandered away; talked constantly; her answers showed that her memory was poor for recent events, and there was evidence of gradual mental deterioration.

Death was due to purulent parotitis and bronchopneumonia. Besides these, the autopsy revealed: diffuse nephritis; pulmonary tubercular nodules; an insufficiency of the tricuspid valve of the heart; numerous uterine fibroids and endometritis; the brain was slightly shrunken in the frontal regions, but no other gross cerebral lesions were found. The histological examination showed a slight chromatolysis of the ganglion cells, neuronophagia, and an increase of the neuroglia.

Case 2, white male, 36 years of age at the time of admission, lived 25 years and a half in the Hospital. The duration of the mental disease at the time of admission was noted as 2 years and 3 months.

His family history was negative; the patient came to the United States when young, entered the army, and, as has been indicated above, exhibited for more than two years previous to his entrance to the Hospital mental abnormalities. Physically and neurologically no pathological conditions were detected. He was quiet, tidy, had little to say voluntarily, but would answer questions; his answers showed that he had delusions of a fantastic nature which were fleeting in character, but which did not, however, appear to cause him any discomfort; he appeared to be indifferent to his surroundings, but in general was satisfied and happy, industrious, and he willingly helped with the ward work; his memory was fair; in general he was disoriented; his delusions concerned God and religion, and combined with these, there

were auditory hallucinations that the "Almighty" talked with him and that other voices abused him, and for that reason he swore at them occasionally; he often talked to himself. Later he became almost completely disoriented; memory became very poor, for the most part he talked unintelligibly, but he gave plain evidence of the existence of delusions; he said that God Almightly persecuted him by ordering him to do things he did not like to do; he occasionally stopped eating in the midst of a meal and explained this as being due to the fact that God had told him to eat no more; he used very profane language and swore at times, and would have nothing to do with the other patients; he asked for whiskey to drink so that in this way he might punish God Almighty; he kissed the walls; he muttered unintelligibly, and he informed a physician that God's voice was inside his body, and that God talked so quickly that he could not repeat what was said; he showed no interest in his surroundings except as exhibited in his daily, almost continuous, polishing of the floor, which he said was done at the command of God; he had practically no knowledge of current events; his reasoning and judgment were very much impaired; he was illogical; his conduct was silly; and his insight was almost lacking.

At the autopsy there were found: marked generalized arteriosclerosis; calcification of the mitral valves of the heart; hypostatic congestion of the lungs; interstitial nephritis; and shrinkage of the frontal portions of the cerebrum.

Case 3, colored male, exhibited mental abnormalities for 5 or more years previous to his admission at the age of 30. Hospital residence was 11 years and 6 months.

Nothing was learned of this patient's family or previous personal history except that it was reported he had been mentally abnormal for at least five years previous to his admission, although his marked mental abnormality was evident for only a year previous to his commitment; during that time he was noted to be melancholy and restless; he showed extreme anxiety and had hallucinations; he upset everything in his room, and was untidy and filthy in habits. Physical and neurological examinations

were negative except that hearing and smell were slightly impaired; his gait was slow and his attitude, although fairly erect and steady, was slightly relaxed; his actions in general were slow, imperfect, uncertain and unreliable. He was quiet, dull, often stupid; he was also untidy; memory was markedly impaired; his ideation was slow and uncertain; in general he answered fairly well, although at times irrelevantly; his reasoning and judgment were bad; he appeared to have very little mental capacity; no hallucinations or delusions were observed and could not be detected from his actions; he was unappreciative and had no apparent interest in his surroundings; he appeared stupid; he usually sat in one place and assumed one position; he spoke only when spoken to, and then only after much persuasion; at times he was noisy, turbulent, talked incoherently, and was destructive; echopraxia, mutism, negativism and catatonia were observed, but none of these conditions was marked; orientation was lacking.

The patient died of tubercular pneumonia, and shrinkage of the frontal lobes of the cerebrum was also found at the autopsy.

Case 4, white male, entered the Hospital at the age of 54 and lived for 18 years.

He fought in the Civil War and since its ending (he was twenty-two years old at that time) was abnormal, with intervening lucid intervals; the character of his abnormality during this period of twenty-one years was not very clear, but presumably it was of a precox nature. On his entrance to the Hospital he was untidy; he answered irrelevantly; he exhibited poor memory; he said little; he went out walking daily; at times he would not keep his clothing on and was filthy in habits. Later the patient was found to have interstitial nephritis, and for about seven years before his death he was almost entirely confined to bed on account of this pathological condition and heart disease; he became much demented, took no interest in his surroundings; questions often remained unanswered, but if answers were obtained, they showed no grasp of his surroundings and were given in a slow, hesitating manner and in so low a voice as to be almost inaudible and unintelligible; he talked to himself a great deal and appeared to have

auditory hallucinations; occasionally he arose from his bed and peered about the ward; echolalia was present; he remained most of the time in bed motionless with his arms across his chest and his fingers intertwined.

Death was due to purpura hemorrhagica. The autopsy showed: some heart disease; atheromatous aorta; small cysts in the kidney; hypernephroma; chronic cytitis; the section of the brain revealed no lesions except atrophy of the anterior convolutions.

Case 5, colored male, lived for about 2 years after admission at the age of 23.

A brother and sister had spasms in early life; otherwise the family history was negative; he attended school for five years, but made little progress; he drank alcoholic liquors to excess and sometimes was drunk two or three times a week; he had gonorrhea several times and a chancre a year previous to his admission; he was arrested on account of a brawl and sent to the workhouse, where his mental condition was recognized as abnormal. From there he was sent to the Hospital, where he was excited; he said that another inmate had shot some dope or chloroform into him, that all the other prisoners were dodging about to avoid it, this was blown at him through a long stem, and he could not sleep and felt queer; he believed he would have been killed by it if he had remained, for he heard them talking about "kill that nigger," and he became frightened and excited; bells were also rung in his ears, voices asked him how he felt; he believed some one was after him trying to read his mind; he said that the poisoned stuff which was being shot at him he could feel, smell, and taste, but could not see the dust of it, and could not see the people; some nights he jumped out of bed because he thought electricity was being used upon him and for several days he had the feeling of things crawling over his body like insects. The physical and neurological examinations revealed no abnormalities except a complete positive Wassermann of the blood serum; he was uneducated, and his general information and memory were poor, but he exhibited a good memory for occurrences in his own life; at first he was quiet and orderly;

he was tidy in habits; he helped with the ward work; he appreciated his surroundings; he answered questions promptly, but talked little with the other patients; and he appeared to be somewhat depressed. Later he became sullen; he stood in various places about the ward; he was slow in movements and showed a tendency to remain in one attitude for a considerable length of time; he took no interest in what went on about him; he never spoke unless spoken to; he was disoriented for time but oriented for place and persons; he had auditory hallucinations of voices which seemed to come from his stomach, and which were interpreted as the spirit of God talking to him; the voices said different things, but he could not, or would not, recount any particular thing; insight was lacking; pulmonary tuberculosis was diagnosed three months before death.

The autopsy showed: pulmonary and intestinal tuberculosis; fibrous deposits over the small intestine, and infiltration of the mesenteric glands; slight shrinkage of the anterior portions of the cerebrum, but no other gross cerebral lesions on section.

Case 6, white male, was 25 years old at the time of admission and lived 28 years subsequently.

No family or previous personal history was obtained except that the patient exhibited mental abnormalities for a month previous to his admission; during his Hospital residence he became gradually demented and exhibited periodic variations in his behavior. At one time he would be quiet and orderly, and he would sit or stand for hours at a time in one place; for the most part he was tidy in his habits; he seldom answered and volunteered no information; he appeared to be dull and stupid and in almost a semi-conscious condition. This state would last for a week or two and be replaced by one of general activity; he sang loudly and irrationally nearly all night; he was restless, destructive, and untidy in dress and habits; he ran around the ward moving or picking up everything he could reach. At times his face was expressionless and at other times he appeared to be very much depressed; his talk was unintelligible, and he mumbled to himself continually; it was judged that he had auditory hal-

lucinations because at times he turned his head suddenly to the right or left and muttered unintelligibly or excitably as if he were talking to or scolding some one; some of his mutterings which were heard indicated that he believed some one was after him and wished to harm him; he showed no interest in his surroundings; he could not be made to work; his memory was poor. In his later years it was noted that he "exhibited no marks of intelligence"; he either did not understand questions or could not make himself understood; his clothing was disheveled; he was filthy in habits; and when he could he stole from his fellow patients; the only reaction which was often elicited when he was spoken to was the opening and closing of his eyes.

Death was due to pulmonary tuberculosis; in addition to this condition, cardiac atrophy and atrophy of the anterior portions of the cerebrum were noted at the autopsy.

Case 7, white male, 36 years of age at the time of admission; had exhibited mental abnormalities for 4 or more years previous to his admission, and lived in the Hospital for 7 years.

This patient was a wife murderer who showed the following evidence of insanity immediately after his imprisonment for life; he was melancholic; he was unconscious of his surroundings; he answered in monosyllables when at all; part of the time he would not talk and he was noted to have a treacherous disposition. Whether or not the murder of his wife, for which he was convicted, was due to paranoid ideas was not determined, but in view of his later history this seems probable, and the psychosis may have begun many years previous to the date assigned above. His expression was dull and indifferent; his attitude was stooped and careless, and he walked in an apparently reckless and slovenly manner. Physical and neurological examinations showed no abnormalities of importance. On admission he recognized what was said to him; he knew where he was; he exhibited a fair memory; he rubbed his hair and face, twisted his mouth, grinned meaninglessly and hummed to himself; he attempted to strike an attendant with a shoe; but at this time no delusions or hallucinations were detected; he was restless, continually moved about

the ward, he walked rapidly and in an excited manner; he wanted his own way, but otherwise was apparently indifferent to what went on; he rarely spoke voluntarily, but sometimes sang to himself; he was noisy at times and at other times appeared to be depressed; he was clean in habits; he butted his head against the door and walls of his room; false hearing was suspected on account of his frequent talking to himself; he used abusive terms towards parts of the room in which no one was present; he would not tell what or who was bothering him; he shouted vile names; he answered general questions, although this was done in a surly manner. Later his hallucinations and delusions became more evident; he believed that a woman was after him, that she came into his room at night to bother him; he called to her out of the window, using a number of names indicating her indecent character; he also bawled at some chickens which he believed were on the floor under his feet, and he attempted to "shoo" them away and to stop their cackling; a month later a swelling of his feet and legs was observed, and at that time he was frequently found on his hands and knees on the floor looking under the bed for the dogs which he believed were there and upon which he stepped; at this time he admitted having auditory hallucinations (of voices); and also visual hallucinations (of ghosts and people) when he closed his eyes; he assumed catatonic attitudes; he exhibited numerous mannerisms, and at times had impulsive outbreaks; at the same time he was negativistic; he was found to have pulmonary tuberculosis, and death was due to this.

In addition, the autopsy showed: intestinal tuberculosis and some shrinkage of the cerebral convolutions anteriorly.

Case 8, white male, had exhibited mental disturbance for more than 6 months previous to his admission; he was aged 30, and lived 2 years and 8 months in the Hospital.

His family history was negative; the patient had attempted a criminal assault and was convicted for this; in the last few months of his term in prison he developed a disorderly temperament; he laughed when questions were asked; he refused to wear

clothing and to obey orders, and occasionally to eat. The physical and neurological examinations revealed nothing of importance except a distended, tympanitic abdomen and stumbling over test speech phrases. On admission he conversed with a physician pleasantly, but appeared to be suspicious; he had notable mannerisms of gritting his teeth and drumming on the table with his fingers; he was neat and tidy; he believed his family had been sent to the same prison as he; at times he became irritable and was pugnacious, especially when another patient walked in front of him, and because of this he had several altercations with them; he expressed the belief that he was some kind of a Mason, although he had not been initiated into or by a regular lodge, but had been "admitted through another personality"; his replies indicated that he believed his personality changed from day to day, although he said he could not reveal the secret of this because it was Masonic and military; in general he was well oriented and showed fair memory and considerable general knowledge, but he had no insight into his condition; he refused to answer many questions on the ground that they were "too easy"; at various times he said that the Government owed him money, that he was a rich man, and that he used to travel about a great deal; he continued to be reticent about his previous life and his ideas, but was cross and disagreeable; he refused medicine and food, and many times fought with the attendants and with the other patients; hallucinations of any kind were not recorded as having been evident; he frequently complained of abdominal pain and suffered from distention of abdomen; an operation was planned, but not performed on account of the sudden death of the patient from intestinal obstruction and gangrene.

In addition to the diseased conditions which caused his death, the autopsy revealed fatty changes in the liver and slight shrinkage of the anterior portions of the cerebrum, with no other gross cerebral lesions.

Case 9, white male, admitted at the age of 34 and lived nearly 20 years in the Hospital.

The mental diagnosis which was made was "probably cerebral syphilis," but later this was changed to dementia precox, prob-

ably paranoid form. The certificate on entrance stated that the patient had visual hallucinations and delusions of persecution but no maniacal explosions, although he talked incessantly about the loss of some musical instruments; he also had hallucinations, which were nocturnal in character, of seeing women coming to the beds of patients who were in the same ward with him. He admitted having had a soft chancre at eighteen, and gonorrhea at nineteen; the physical examination was negative except for irregularities and inequality of the pupils; there was no disorder of voluntary movement, or of the reflexes or of sensation; there were hypertrophy of the heart and lesions of the valves. He smiled constantly, his expression was dreamy but fairly intelligent; no peculiar actions were noted; he reported that soon after his arrival at the Hospital he was given some black medicine which injured his health, making him nervous and giving him pains in the legs like needles, and causing him to spit, which made his tongue sore; subsequently, no delusions were elicited except a brief mention of this supposed poisoning episode. Thirteen years after his entrance, it was noted that he was not depressed; he talked and associated with the other patients; he played games of different kinds when on the ward, and also played a musical instrument; he sat quietly; he was not overly religious; he did not assume peculiar attitudes; he was tidy in habits; he did not lack in initiative; his memory for recent and old events was good; he was not agitated as a result of any of his delusions; he did not become excited, abusive, profane, destructive or untidy; he slept well; his conversation was coherent; he had parole of the grounds; he was well oriented; he appeared to be content; he never complained, and he played in the Hospital band. On several occasions later he became restless and very much confused, being unable to comprehend what was said to him and seeming to be much disturbed; one of these attacks immediately preceded his death. During the later years of his life he showed marked loss of intelligence and very little judgment; it was difficult to get his attention, and when his attention was obtained, it was almost impossible to hold it; he showed much retardation; he spoke indistinctly, and at times his teeth were kept closed so

that it was difficult to understand what he said; he also seemed unable to comprehend some of the simplest questions, and when asked to repeat one which had been asked, he was unable to do so; he remained orderly, but took no interest in his surroundings; he was neat and tidy; he was also fairly well oriented in all spheres; he had fair memory of his personal history, but of other events his memory was very poor.

Death was due to cardiac valvular disease. The autopsy showed that he had: hypertrophied heart; marked aortic atheroma; mitral aortic valves contracted; pulmonary tubercular scars and pulmonary hypostasis; nutmeg liver; some adhesions in the region of the appendix; brain shrinkage over the anterior two-thirds of the convolutions, but no other cerebral lesions; and a slight sclerosis of the large vessels at the base.

Dementia Precox, Discussion

Although these nine cases have somewhat different clinical symptoms, the symptomatology of all is sufficiently alike to warrant the clinical diagnosis of dementia precox. The form of the disease, it should be remarked, is not the same in all cases, five being judged to be catatonic (3, 4, 5, 6, and 7), and two to be paranoid (1 and 8). Cases 2 and 9 were committed to the Hospital many years ago. The case histories of these patients contained no, or very meagre, information regarding their mental conditions previous to commitment, and only outlines of their behavior during their early hospital residence. We are not entirely justified in making a definite diagnosis of the form of precox from the information obtained in their later years, but the general diagnosis of precox is, however, justified by the accounts which have been kept, and the symptoms recorded in the records during their later years might be interpreted to indicate that case 2 was a paranoid case, and case 9 an hebephrenia.

Looking at these cases from another point of view, it will be noted that the anatomical lesions do not correspond with the clinical forms. Of the three cases in which the brain was noted to have shown frontal atrophy one was diagnosed as paranoid, a second as an hebephrenic and the third was a "possible paranoid"

case. Of the five cases with anterior atrophy the mental diagnosis of catatonia was made in four, while the fifth was a paranoid case. The ninth case, with atrophy covering the anterior two-thirds of the cerebral convolutions was the case mentioned above as possibly hebephrenic. The only evidence of a possible correlation between the forms of precox and the character of the cerebral atrophy is the fact that most of the cases of lesions of the anterior convolutions are catatonic. This might be taken to indicate that motor disturbances in catatonia may be associated with pathological changes in the anterior portions of the cerebrum, but case 8, whose brain also exhibited similar lesions did not exhibit these behavior disorders. It should also be remembered that case 9, in whom the atrophy covered slightly more of the cortex than in the catatonics did not exhibit motor disturbances of the nature of catatonia. These two cases (8 and 9) are sufficiently definite to prevent a generalization regarding the relations of such anterior lesions with motor disturbances of the nature of catatonia or negativism.

During their Hospital residence all of these patients were noted to show gradual mental deterioration, although the amount of this decadence differed in the individual cases. The histories show that cases 2, 3, 4, 6, and 9 showed towards the end less evidence of being thinking beings than the other four cases showed. Excluding case 4, whose age at the time of death was seventy-two, and whose lack of mentality might have been due to the natural decadence associated with old age, the other four cases are not chronologically aged, and, in fact, of the other cases there were two (1 and 7) whose ages were respectively greater than those of cases 3, 6, and 9, and case 3. While the degree of atrophy in these five cases is not specified, even roughly, there is nothing to indicate any definite relation between the greater mental deterioration and the degree of atrophy. It is true that the brains of cases 1, 5, and 8 are described as showing only "slight" atrophy, but case 7, in whom extreme mental changes were not found was also described as showing "some" atrophy, which term may be interpreted, as I interpret it here, to indicate only a medium degree, rather than a slight degree. No mathematical

estimation has been made in the individual cases regarding either atrophy or mental deterioration, and the data at hand do not permit the correlation of these two conditions at the present time.

It is, however, of interest and importance to note that the degree of dementia in those cases in which the frontal lobes were atrophied did not differ to any appreciable extent from those cases in which the atrophic regions were larger. Thus case 2 has been described as exhibiting no knowledge of things occurring about him, and case 3 to have "very little mental capacity," although the latter patient at the time of his death was only forty-two years old. In addition, it has been noted that case 1 had a poor memory.

Although the degree of dementia, or mental abnormality, does not appear to be directly correlated either with the extent or with the degree of the atrophy in the cases which we have studied, we may seek for correlations in the individual mental symptoms. Differing in the individual cases, and giving, as they do, special characteristics to the disease, the mental symptoms can not be dealt with in great detail. Nor can the individual elements of the mental processes be considered, for in the clinical histories the complex mental states or processes have not been analyzed into their elements. This is, however, not different from the methodological condition found in most clinical work, *e.g.,* in neurology, and the attempts at correlation of the complex processes with cerebral lesions may therefore well be attempted regardless of the lack of analysis of these complexes.

Underlying all diagnostic methods in psychiatry are the assumptions that mental states are mirrored by acts, that acts change in accordance with the mental states, and that changes in mentality, which are supposed to be produced by or correlated with functional or anatomical cerebral lesions, are evidenced by alterations in general behavior. In their general form these assumptions may be satisfactory, but when they are made more specific they become open to criticism. In the cases which have been described above this latter appears to be true. It will be noticed that four of these patients have been described as tidy in habits, while four others have been described as untidy or

filthy, while the ninth has not been specifically described but appears to have been tidy. Two of the untidy patients were those in which only the frontal regions were atrophied, and two in which the anterior lobes were shrunken. Case 9, in whom the atrophy extended farther backwards than in the other eight cases, was, however, noted to be tidy. In this respect there is correlation neither with the extent nor with the degree of the atrophy.

Although the frontal lobes are believed to have more direct relations with motor processes, the data at hand regarding the motor manifestations, other than the catatonic attitudes, etc., in these patients do not appear to be correlated with the lesions. A comparison of the movement differences in the patients under consideration shows that the variations are not variations corresponding with the regional atrophies. Certain of the patients varied from a quiet to a restless state; others were almost continually restless or noisy; and two were noted to be uniformly slow, unresponsive, and, during part of the time, motionless. Some may be inclined to interpret the general motor manifestations to be evidence of a supposed inhibition function of the frontal regions of the brain, in some of the cases there being a greater amount of inhibition, and in others a lesser amount of inhibition than in normal individuals. The fact that the variations were not always in the same direction in the different patients, would, however, be a matter needing special explanation in addition to the general hypothesis. We should, on the basis of our present knowledge of the motor functions of the cortex, be able to explain or to correlate these irregular weekly or monthly variations in activity in the same patient with exaccerbations in irritation or degeneration of the ganglion cells, but the pathological facts which would warrant such explanations or correlations are lacking. One element, which appears to the writer to be important in this connection is that the motor phenomena in the cases under consideration did not differ very greatly. If these motor disorders were due principally to the pathological conditions of the cells in the atrophic areas, we should expect to find greater motor disturbances associated with

those atrophies which were of the greatest extent, or at least we should expect that the motor activities in those patients in whom the precentral, or physiological motor, area was involved should be more greatly changed than in those in which only the frontal lobes were atrophied. Such, however, is not the case. There is, as has been written above, no apparent difference between the motor derangements in those patients with frontal lesions and those with lesions which also involved the precentral areas, nor even between the motor phenomena in the case with frontal lesions and those in the one case in which the atrophy also involved the precentral areas and parts of the parietals in addition to the frontals.

Certain clinico-neurological facts have been interpreted to mean that the activities of the frontal lobes are especially associated with emotional states or emotional expression, and were this true, different degrees of frontal lesions might be expected to result in variations in emotional tone or in the character of the affective conditions. In these nine cases, however, the emotional conditions were somewhat similar, in that it was variable in all. It varied from depression to indifference, and occasionally to a high degree of happiness. Many of the affective states in these patients depended upon, or resulted from, or, to speak accurately, accompanied, and corresponded with, delusions, and it is not possible to separate the affective elements from these other mental states. Neither the degree nor the extent of the cerebral changes appears to be correlated with the intensity, character or variability of the affective states, for the fear and suspiciousness of cases 1 and 5, in which only slight atrophies respectively of the frontal and anterior convolutions were noted, did not differ from similar states in patients 3 and 7, whose brains showed corresponding areal distributions, but with slightly increased degrees, of atrophy. An examination of the case histories also shows that the fluctuations from one affective state to another is not associated with particular degrees or extents of the lesions.

Notable variations both in the presence and in the characters of hallucinations were also recorded. Of the nine patients, four

exhibited plain evidence of auditory hallucinations (cases 1, 2, 5, and 7). Two others (cases 4 and 6) appear to have had auditory hallucinations, although this is not as certain as in the other four cases. The presence of auditory hallucinations in case 4 has been inferred from his talking to himself, and similarly in case 6 because he mumbled to himself and because he had been noted to turn his head towards a special part of the room and appeared to listen when no one was present there. Definite evidence of visual hallucinations was found in only two of the cases; viz., patients 7 and 9, and in one of these it has been noted they were more frequently present at night. Patients 1 and 7 also exhibited actions which were interpreted to mean that they had tactual hallucinations or paresthesias. Patient 1, it will be remembered, reported that she could give out electrical power, and that electric currents had been turned upon her. Patient 7 complained of chickens and dogs which he thought were in his room and which he was compelled to step upon when he got out of his bed. Whether or not the latter case is a mixed hallucination, *e.g.*, tactual and visual, was not determined. The actions of the patient indicated that he did not see the animals, for he searched for them under his bed. Case 3 was reported to have had hallucinations previous to his entrance to the hospital, but during his Hospital residence these were not discovered. In the case history of patient 8, in whose brain the atrophy extended over the anterior portions, no hallucinations were recorded at any time.

With the exception of cases 3 and 4, these patients were noted to have delusions. It may not be definitely stated that patient 3 did not have a delusion of any kind, for there is internal evidence in his case history that mental abnormalities of this kind may have been present. It is stated, for example, that in the year preceding his commitment to the Hospital he was restless and melancholy and exhibited extreme anxiety. The reasons for these affective states are not mentioned, but it appears doubtful that they were independent of ideas of impending harm, or of persecution or the like. None of his actions during his Hospital residence was indicative of the presence of a delusion, although

during those years he was observed to fluctuate between excitement and mutism. Case 4 was also judged to be free from delusions during the period of his Hospital residence, although the general facts regarding his mental condition for 21 years previous to his admission are not sufficient to warrant the statement that delusions had not been present during that period of time. The considerable degree of dementia which was present during his Hospital residence may have made the expression of delusions difficult, but his reactions to the auditory hallucinations from which he suffered would not lead to this conclusion. The characters of the delusions of the other seven cases ranged over the fields of somatopsychic, autopsychic, and allopsychic. Delusions of persecution were the more frequent, but these alternated with delusions of grandeur in some cases. None of the somatopsychic delusions was definitely associated with corresponding pathological physical conditions, with the possible exception of those of case 7. This patient complained that chickens and dogs were on the floor of his room, and that he had to step upon them when he rose from his bed. The physical condition associated with this delusion was a swelling of the feet, and as has been suggested above, the hallucinations and the delusion may have resulted from the stretching of the skin. The association of the different characters of delusions with the cerebral atrophies in these cases is neither constant nor definite, cases 3 and 4 belonging respectively to the frontal and anterior atrophy groups, so that we are forced to the conclusion that the lesions can not be constantly associated with delusion formation. These results are of interest in connection with Southard's studies of delusions and especially with his conclusion that the presence of delusions is "to be correlated more with lesions of the anterior association center."[4]

Regarding the conditions of memory in these patients there is little information. Six of them were unable to recount recent events or events in their own lives, or were unable to repeat simple questions which had previously been asked. The other

[4] Southard, E. E. The Mind Twist and Brain Spot Hypotheses in Psychopathology and Neuropathology. Psych. Bull., 1914, 11, 117-130. See especially p. 123, and other references there given.

three cases exhibited a fair degree of memory. Whether these apparent memory defects were due to lack of attention or to inability to retain the impressions which were received can not be decided. All the patients with simple frontal lesions, irrespective of the degree of atrophy, had poor memory, whereas patients 4, 7, and 8 with anterior atrophies exhibited fair memory.

In contrast to the memory defects of these patients the degree of orientation is to be noted. Although orientation depends, at least to a certain extent, upon retention, it is not necessarily associated with general memory ability. This is shown in case 9 where memory appeared to be very defective, although he was fairly well oriented in all spheres, and in case 5 who, although disoriented for time, was oriented for place and persons. On the other hand patient 4, who exhibited a fair degree of memory, had no grasp of his surroundings. The relation of orientation ability to the lesions in the nine cases is not definite, case 1 being opposed in this particular to cases 2 and 3, and cases 5, 7, and 8, showing good orientation while the corresponding cases, 4 and 6, were in general disoriented. Case 9, in which the atrophy extended beyond the anterior region, was also noted to be fairly well oriented.

The ability of the patients to attend to stimuli is not mentioned in all of the case histories, but reading between the lines, it is evident that this was poor. It is possible that some of the apparent memory defects were due to lack of attention, and that certain of the other mental disturbances were also caused by the failure to attend to stimuli. It is also possible that the degree of dementia is correlated to a certain extent with the failure to attend.

When the facts of atrophy and the facts of mental abnormalities in these nine patients are taken together, it is seen that there are decided differences in the character of the psychic symptoms associated with similar cerebral lesions. It is also apparent that regardless, of the extent of the atrophies similar mental symptoms may be evidenced. The conclusion that follows, therefore, is that similar cerebral lesions in cases of dementia precox do not always result in similar forms of the disease, nor in similar symptoms in all individuals, nor in the same degree of dementia.

GENERAL PARALYSIS OF THE INSANE, CLINICAL HISTORIES

Case 10, colored male, was admitted to the Hospital at the age of 30, and lived over 4½ years.

There is nothing of importance in the patient's family history, and the only facts of interest in his personal history is that he admitted gonorrhea, denied having had syphilis, and admitted that he had used alcoholic liquors since he was a boy, but said he had never been drunk. The physical examination revealed nothing of interest, except that there was a complete positive Wassermann of the blood serum and a trace of the reaction in the cerebrospinal fluid. He had diminished knee jerks, sluggish reactions and inequalities of the pupils, well-marked tremor of the tongue, lips and facial muscles; speech was somewhat ataxic, and there was difficulty in repeating test phrases. The onset of the mental disturbance appeared to be a sudden one; he had been working as a waiter two days before his arrest; he said he had found a check which called for $30,000,000, on the back of which there was a notice to return it to the bank and receive $1,000,000 for it; the bank was closed but he showed it to a number of people and tried to get $300 for it; one man gave him $500 for it, but a policeman arrested the patient, took him to a hospital and later he was brought to this institution. How much of the above incident was based upon a minimum of fact was not determinable. On entrance his expression was one of exaltation; he was quiet and cheerful; his habits were tidy; he gave no trouble except slightly by constantly requesting that he be permitted to be allowed to go out so that he could get his money; he was well oriented for time, place, and persons; his attention could easily be attracted and held; he comprehended what was said to him, and answered coherently and relevantly, except when his delusional ideas were touched upon, whereupon he became rambling and disconnected in conversation; his mem-

ory for recent and remote events was good for one of his grade of intelligence; his emotional tone was one of exaltation, he was as "happy as a lark"; he was sociable with the other patients and worked on the ward; no hallucinations could be elicited. Later, he had a period of confusion for a few hours, in which he took the dishes from the table and placed them outside of the window (reporting that he thought thereby he would get some tobacco), and attacked one of the nurses and demanded his keys; his delusions of wealth had not changed materially; subsequently he had convulsions, was then confined to bed, and developed contractures. At that time he spoke rarely and then only a few phrases, he took no cognizance of what went on and led a nearly vegetable existence till his death from exhaustion of paresis. The autopsy showed that the cerebral convolutions over the frontal regions were shrunken.

Case 11, colored male, had been known to have mental abnormalities for at least 7 months prior to his admission at the age of 37, and he lived for nearly 2 years in the Hospital.

His family and personal history were not obtained in any detail, for he could not give much information and what he gave appeared to be rather unreliable. He denied a syphilitic history, but was found to have a scar on his penis due to an old sore; the Wassermann reaction with the blood serum was complete positive, with the cerebrospinal fluid a trace, the number of cells in the cerebrospinal fluid was 170 per cu. mm. The neurological examination showed marked tremors of the tongue and fingers, and somewhat generally throughout the body; station and gait were tremulous and impaired, he was unable to stand on one leg; coördination was impaired; there was a marked speech defect; some of the reflexes were diminished, others were absent; the pupils were unequal and reacted only slightly to stimuli. He appeared to be contented and did not seem to worry; he sat in a listless, though cheerful, mood, and paid little attention to his surroundings; he did not appear to be oriented; he obeyed simple

commands, but when questioned he did not answer at times; he was tidy in his dress and in his habits and did not conflict with his surroundings; he believed he owned a race horse for which he had paid $3,000. He had a brief attack of unconsciousness followed by a period of confusion in which he talked to himself and made signs with his hands. Physically and mentally he declined, until he was unable to do anything for himself; he replied to no questions, and was apparently oblivious of his surroundings. Death was due to exhaustion of paresis. The autopsy also revealed pulmonary tuberculosis, pericarditis, atrophy of the heart valves, fatty degeneration of the liver, chronic cystitis, and general shrinkage of the frontal lobes. The microscopical examination showed that the frontal and central convolutions exhibited the characteristic pictures of paresis, but that the parietal lobes did not show any marked changes.

Case 12, white male, had been suffering from mental disease for at least a year previous to his admission at the age of 51; he lived 2 years and 8 months after his admission.

The only fact of interest in the family history was that his mother had died of pulmonary tuberculosis when the patient was eight months old. He received a high school education, and after serving for eight years in the army, was a clerk. He had contracted syphilis thirty years previous to his admission and had gonorrhea at a later period, but subsequently married and begot three healthy children; he used tobacco to excess. About a year previous to his admission he became mentally fatigued very easily, his memory was impaired; he could not comprehend as well as he formerly could; his speech became indistinct; his writing was careless, showing many omissions and mistakes in spelling; his gait was ataxic. At the same time he became morose, sullen and irritable; he worried over the state of his health; he made remarks about killing the members of his family and himself; he also bought immense quantities of perfumed soap and bathed constantly. The neurological examination showed coarse tremors of the facial muscles and twitchings of the thigh muscles; Romberg sign was present; gait was unsteady; the

knee jerks were not elicited; the Wassermann reaction with the cerebrospinal fluid was complete positive; the number of cells per cu. mm. was 20. On entrance to the Hospital he appeared to be cheerful, contented and appreciative; but was inclined to be fault-finding with his surroundings and fretful that he was not permitted to have all his clothes and his special toilet articles in his room; he kept busy washing his hands and face and combing his hair; he appeared to be bewildered at times, and expressed the belief that he had offended some one and he worried about this; in general, he showed no interest in what went on about him; his memory for recent and remote events was poor; no evidence of the existence of hallucinations or delusions was discovered; his habits were tidy; he was usually quiet, but at times was nervous. Later, fantastic and ridiculous delusions of a grandiose type were evidenced, *e.g.*, he was to take a marvelous train ride through the country, he had invented things, etc. At times he became worried, he wanted to shoot a fellow patient, whom he believed to be an enemy; he imagined people were going to do something mean to him, that they came to take away his trunk in which he had his money, he also spoke of being tired and explained that this was due to his having had to fight negroes during the night; he became untidy in habits. The depressive delusions apparently disappeared, leaving only those of a grandiose type, that he owned the Hospital, had immense amount of money, etc. He became much demented, he was bedridden, contractures of the left arm and leg developed, there were no convulsions; death was due to exhaustion of paresis. The brain showed great atrophy in the frontal lobes.

Case 13, colored male, admitted to the Hospital at the age of 41, lived for 3 years and 2 months subsequently. The duration of mental disease at the time of admission was about 2 years.

The family history was negative. The medical certificate stated that the patient had had syphilis; mentally he had a violent temper and was very irritable; he had been melancholy, and had exhibited delusions and homicidal tendencies. Physical ex-

amination showed only a slight heart involvement, Wassermann reactions with the blood serum and the cerebrospinal fluid were positive, there were 65 cells per cu. mm. in the cerebrospinal fluid. The neurological examination showed irregularities in outline of the pupils; tremors of tongue, lips, eyelids, and extended fingers; patellar reflexes were very much diminished, and there was a Babinski phenomenon on the right; his station was poor; there was hyperextension of the legs at the knee; the gait was slightly ataxic; coördination was poor; and there was a marked speech defect. His facial expression was placid; he was orderly and quiet, he had little or nothing to say voluntarily; he was indifferent and inclined to be stupid; his attention was easily obtained and held; he comprehended questions and answered coherently and correctly, but slowly; he was not oriented for place, time, or people; his memory was very defective; his judgment was poor; he lacked insight; emotionally he was neither exalted nor depressed, but rather indifferent and apparently satisfied; he did not associate with the other patients and manifested no interest in his surroundings; no delusions or hallucinations could be elicited, nor were they judged to be present because of his conduct. Later he was restless, disturbed and at times noisy; he talked to imaginary people, but recognized no one who saw him; dementia became profound; he comprehended little; his conversation was rambling and incoherent; occasionally he expressed some words indicating that he had grandiose ideas, that he possessed houses and diamonds; at times he became disturbed and noisy; and often was restless, destructive and filthy; when he walked, his gait was very ataxic. The autopsy examination revealed shrinkage of the cerebral convolutions, especially in the anterior parts.

Case 14, white male, was admitted at the age of 33 years, and lived 8 months; his mental disease was evident for more than 2 months previous to his admission.

The medical certificate stated that the patient's father died of tuberculosis, but this was the only interesting point in the family history. A comrade reported that the patient had acted

peculiarly for several months. The patient denied that he had used alcoholic liquors. He showed tremors of the lips, tongue and hand, difficulty in speaking, some impairment of intellect, muscular weakness, diminished knee jerks, and Romberg sign. The Wassermann reaction with the blood serum was completely positive, the cerebrospinal fluid contained 145 cells per cu. mm. On admission the patient would not talk, and his lack of coöperation prevented a careful examination of his mental condition. He had a very stupid, blank expression, stood or sat in a stiff, unnatural position until told to do somethig; several times he rose from his chair and started towards the window as if governed by some idea, but at command he readily resumed his seat; jerkings of different muscles were observed; if undisturbed, he closed his eyes as if going to sleep; he did not apparently know how to hold a pencil and his first efforts at writing were scribbles; his movements at unbuttoning his coat were incoordinate; there was no evidence of apparent purposefulness in any of his movements; his attention was obtained and held with difficulty; he appeared to know the name of the Hospital; on account of his non-coöperation it was impossible to determine anything about the character of his memory, or the presence of hallucinations or delusions. Later it was noted that he was tidy, disoriented for time, place and persons, his memory was very poor; he could not find his bed, etc.; he did not answer questions readily and seldom talked. He was confined to bed and died of exhaustion. The autopsy revealed shrinkage of the anterior cerebral convolutions, hypostatic pneumonia, interstitial nephritis and purulent cystitis.

Case 15, white male, was noted for one month previous to his admission to exhibit signs of mental abnormality; his age was 38, and he lived in the Hospital for 1 year and 6 months.

The family history obtained from the patient contained nothing of importance. The medical certificate accompanying him stated that he had syphilis six years previously, but this was denied by the patient; the Wassermann reaction with the blood serum was complete positive, also with the cerebrospinal fluid;

the number of cells in the cerebrospinal fluid was 16.5 per cu. mm. The patient had tuberculosis during his residence in the Hospital. Previous to his admission his ward mates in another institution had complained of his irrational conduct and conversation. He had a feeling of well being and of importance, with delusions of grandeur, but no delusions of persecution or hallucinations; in addition to the tuberculosis it was found that the patient's pupils were unequal, the left reacted neither directly nor consensually to light stimuli; the patellar reflexes could not be elicited; coördination was good, there was a slight Romberg sign and wavering gait. He was oriented for place and persons, and mostly for time; his general memory was poor for both recent and remote events; he could not tell the times and places of his occupations; he showed no insight into his condition and said he thought his admission into the Hospital was a "frame-up"; an occasional slight buzzing in his left ear was the nearest to an hallucination that was detected; and no delusions other than that recorded above; his general intelligence was poor; he was irritable, easily angered when questioned and swore fluently; in general, he appeared to be happy; he emitted loud screams occasionally, but no reason for these could be obtained; his writing was ataxic, his speech was tremulous; he became untidy in habits; did not talk voluntarily; he became much demented and enfeebled. Death was due to pulmonary tuberculosis. The examination of the brain showed that the convolutions were shrunken over the anterior half.

General Paralysis of the Insane, Discussion

Of these six cases, three had atrophies in the frontal region and three were of the anterior portions of the cerebrum. Only one of these has been described as showing a great degree of atrophy, viz., case 12. All of these patients showed a very great degree of dementia previous to death. The one who seemed least demented was case 13, although the degree of dementia can not be determined with accuracy. It is of interest to note that the total duration of the disease in this patient was longer than in the other five patients, and the dementia

appeared to be more gradual in its appearance. With this case there should be compared case 14, who lived less than a year after the first signs of mental abnormality. Most of these patients towards the end lived practically a vegetable existence; they were oblivious of their surroundings; they reacted little, if at all, to ordinary stimuli and were apparently unable to comprehend anything. These general mental conditions which are found in all cases of paresis are not, however, correlated with the degree or with the extent of the atrophy of the brain, for the patient (case 15) whose brain showed the greatest amount of atrophy was no more demented than the other patients at the time of death, nor was the patient (case 12) whose brain showed the greatest degree of atrophy any more demented than the other patients. Both of these cases showed an extreme degree of dementia, and in this respect they differed not at all from the other cases (with the possible exception of case 13, which is mentioned above).

It is to be noted that all of the patients exhibited motor derangements. With the exception of case 15, tremors, especially of the lips, tongue and hand, were found. Case 15 did not show tremors of these parts, although his writing was tremulous and associated with this there was a certain degree of ataxia. It does not appear, however, that the ataxic gait and the inability to walk steadily and to perform other necessary movements were any greater in those patients who exhibited lesions extending beyond the frontal lobes, and in this respect we find no definite correlation between the atrophies which included the electrically excitable (*i.e.* motor) portions of the cerebrum and those which did not extend as far backwards. Only one of the six patients had had convulsions, case 10, and this patient it will be remembered was a case in which the frontal regions were atrophied. On the other hand, two of the patients (cases 10 and 12) developed contractures, and it is of interest to note that both of these were cases of frontal atrophy. Periods of confusion or of bewilderment, which are probably similar in nature to the convulsive seizures, were noted in cases 10, 11 and 12, and in one of these (case 11) such a condition was at

one time preceded by a period of unconsciousness. These three cases were those in which only frontal lesions were discovered.

The affective states in these patients were not similar. In general, although they appeared contented, some had feelings of exaltation, and at times some were depressed. Cases 10 and 11 appeared to be almost continually contented and cheerful. Case 15 appeared to have feelings of contentment, of well-being, and of self-importance at practically all times, and, although he complained of having been sent to an institution and called it a "frame-up," his remarks about this matter appeared to have little affective accompaniment. On the other hand, patient 14 appeared to be indifferent, and the only evidence of worry or depression on his part was his disinclination to talk and his lack of coöperation. The reasons for the impulsive tendencies which were noted in his case were not learned, but these were not accompanied by noticeable emotional reactions. Patients 12 and 13 showed variations in affectivity, for they ranged from sullenness, moroseness and homicidal tendencies to those of cheerfulness and exaltation. It will be observed that these variations are not associated with particular lesions, and that similar variations in emotional or affective states are found associated with the more extensive as well as with the frontal atrophies.

In none of these patients were hallucinations noted at any time, with the possible exception of case 15, who had complained of a buzzing in his ear. Whether this was due to a peripheral or a central irritation could not be determined; it did not apparently lead to any interpretative elaboration, and because of this it may be disregarded.

Case 14 showed no evidence of the presence of a delusion at any time. The other five patients were noted to have delusions of grandeur or of persecution, although these were most frequently mild in character and those of some of the patients were not much beyond the scope of the individual's life. In a few instances the delusions were of a very fantastic and absurd character, notably those of patient 10. It appears remarkable, however, that with the exception of the temporary and unsystematized

delusions regarding the race horse (case 11), the possession of houses and diamonds (case 13), and some of grandeur, of which the nature was not specified (case 15) and which were noted only previous to his entrance to the Hospital, these evidences of mental abnormality were not prominent in these three cases. Moreover, it may be mentioned that some of the delusions of patient 12, *e.g.*, those which were evidenced by his complaints that various people were trying to get his money away from him, were not too far out of bounds, and might not have been delusions in the strict sense of that term. In this connection it must also be remembered that with the possible exception of the delusion regarding his retention in the Hospital, which he described as a "frame-up," patient 15 did not show any evidence of delusions during his Hospital residence of about eighteen months. We are led to conclude from the facts which have been recorded that these mental symptoms do not appear to be concomitants of special extent, or of special degree, of atrophy of the anterior regions of the brain, and that delusions, in cases of paresis at least, may not be due to the cerebral changes in the frontal lobes.

It is of interest to note that in these cases the memory differed very greatly. Although the memory of all was very poor during the later weeks or months of their Hospital life, in some cases, even at times when the other evidences of abnormality were plain, *e.g.*, delusions, it was noted that the memory for remote and recent events was fair. Thus, case 10 appeared to have a remarkably good memory for the events of his past life and even for other events which did not so immediately concern him, although his delusions regarding his wealth were very absurd and in this respect his judgment was very defective. Regarding case 14, no information could be obtained on account of his lack of coöperation. The memory in the other four cases may be said to correspond in general with the degree of dementia, although not with the extent or the degree of the atrophy.

In most cases the degree of orientation corresponded also with the degree of dementia, and also with the degree of memory. Patient 10, who recalled quite well both recent and remote events,

was fully oriented for time, place and persons, and in general the other patients who exhibited memory defects were not oriented. One exception to this general statement is patient 15, who, although he could not recall much of his own personal history, was well oriented for place and for persons and also exhibited fair orientation for time. It may also be noted that patient 14, whose lack of coöperation has been mentioned, appeared to know where he was.

At the time of their admission to the Hospital the attention of these patients could be readily obtained, and, in two cases, 10 and 13, it was noted that they could attend to things well. The latter patients understood what was said to them and could carry on a conversation coherently and relevantly, and appeared to be able to attend to such impressions as they received. Cases 11 and 15 also exhibited a fair degree of attention ability, although at the same time it was noted that their memory was defective. On the other hand, case 12 was apparently unable to attend to things well, for he is noted to have been unable to attend to what was said to him or to comprehend readily, and case 14 also exhibited a similar difficulty of attention. These variations, like those in the dementia precox group, are not associated with the special lesions.

These six cases of paresis do not differ extensively from one another in symptomatology, although they may be differentiated as belonging to the simple dementing form (*e.g.*, case 14) or to the expansive form (*e.g.*, case 10) of the disease. Although the symptoms in these cases are more nearly equal than in the cases of dementia precox, the differences are also sufficiently evident to make possible a comparison with the difference in the extent of the lesions. It appears, however, that the symptomatological differences are not to be correlated with the anatomical differences in the extent or the severity of the anterior atrophies. Those patients who exhibited only frontal atrophies were, apparently, as markedly demented, they showed about the same degree of emotional or affective change, and they exhibited lack of memory, of orientation, of attention, and of comprehension to about the

same degree as those cases in which the atrophy extended beyond the limits of the frontal lobes. On the other hand, it appears equally probable that with frontal or with anterior atrophies some paretic parents will exhibit a fair degree of memory and others an almost complete loss of memory, that some will have fantastic or persecutory or grandiose delusions and others will have none of these. It is apparent, therefore, that with comparable lesions the symptoms may differ, and that with lesions which do not even approximately correspond the symptoms may be similar..

ARTERIOSCLEROTIC DEMENTIA, CLINICAL HISTORIES

Case 16, white male, was admitted at the age of 63, and died 7 years and 4 months later.

The diagnosis on admission was acute confusional insanity, intoxication psychosis; the duration was given as three months plus; he was noted as having used alcohol only moderately; the medical certificate stated that he burned papers on the floor of his room; frequently wandered around aimlessly at night; showed loss of memory, with all the symptoms of senility; had fixed transitory delusions, one of his fixed delusions being that he was "still in active service in the army, but at that time on furlough"; he was disoriented for time; he made meaningless remarks. His family history was negative. On admission he was disoriented for time; appeared perfectly satisfied with his surroundings; showed only a slight amount of insight; he was up and about the ward; his expression was placid; he was poorly nourished but there were no physical or neurological abnormalities. His intellect and memory were defective; his attention could be obtained and held without difficulty; he was quiet and orderly; he appeared to be much demented, and seldom spoke unless addressed; he remained seated in one place in the ward the greater part of the day; he comprehended readily, and his replies were given promptly and were relevant and coherent; no delusions or hallucinations were elicited. Later he claimed that some one put laudanum in his beer, and that this had doped him and caused him to be sent here; when asked if any one had put poison in his food since he was in the Hospital, he said it was not for him to say, he became indignant, his face flushed, and he said he had a right to his beliefs; a speech defect was observed. For over a year previous to his death he was confined to bed; he became disturbed and excited if he did not get the things he wanted; he thought some one had

stolen his money, hidden his clothes, and imposed upon him in various other ways; his memory grew more defective, and he was unable to give the name of the institution; he thought some one was sending electric currents through him, and that these caused contracture of his fingers; his feet and legs became contracted about six months before his death.

The autopsy showed atrophy of the frontal convolutions; there was left bronchopneumonia, and the kidneys showed a slight degree of swelling and some inflammation.

Case 17, white male, was admitted at the age of 65 and subsequently lived for a little over a year.

His family and personal history was negative; the medical certificate stated that the patient had been nervous and talked at random about large amounts of money he thought he was going to get from people in England; he made all kinds of absurd statements; he asked to have his feet and toes amputated; he could not carry on a connected conversation and he attempted violence upon other inmates in the Soldiers' Home in which he was. On admission to the Hospital he was restless most of the time; he would not sit for even a few minutes in one place; he appeared to be profoundly demented; he was disoriented; his memory was markedly defective, and his talk was disconnected and incoherent; coarse tremors of the tongue were noted; the pupils reacted slowly in accommodation, and the superficial reflexes could not be elicited; his coördination was fair; physically he showed signs of cardiovascular renal disease and pulmonary tuberculosis.

In addition to these the autopsy showed marked shrinkage of the brain, especially in the frontal regions.

Case 18, colored male, 73 years old at the time of admission, lived for about 1 year subsequently.

The certificate accompanying the patient stated that he had impaired cerebration, and for the preceding six years there had been a tendency on his part to wander away. On his admission

to the Hospital he was found to be enfeebled; he was restless; the only thing that could be elicited from him by questioning was his name; he was disoriented; he talked very indistinctly; he seemed to be very much demented; he was tidy in habits; spasmodic laughing and crying and negativistic tendencies were noted; he showed perseveration; his voluntary acts were apparently purposeless, and his movements were inaccurate; neurologically, there were no atrophies found; a slight arcus senilis was present; there were marked tremors; his gait was slow and unsteady, and his walk was shuffling; he was noted to have some ataxia; although a right homonymous hemiamopia was noted in the history, this was not detectable at a later date and may have been surmised because of special acts due to his negativism and his general mental inertia; sensory and motor aphasia were also noted; smell was diminished; there was a diminished sense of temperature and a hypoalgesia; he was untidy in habits and he could not find his bed; he took no interest in his surroundings, and at the time of his death he was in a condition of extreme dementia.

The autopsy revealed shrinkage of the cerebral convolutions, especially in the frontal lobes, pachymeningitis, slight arteriosclerosis of the basal vessels, valvular heart disease, atheromatous aorta, congestion of the kidneys.

Case 19, white male, was admitted at the age of 62 and lived 16 years. At the time of admission no information was received regarding him except that the diagnosis of "acute mania" had been made.

In the Hospital he was orderly and quiet and assisted with the ward work; he was fond of reading; he spoke very little voluntarily, but answered questions readily; he was untidy in appearance, and he collected and filled his bed with trash; he was very childish; at times he talked almost incessantly. Later he was noisy and restless, somewhat destructive and untidy, and he became hypochondriacal, and sometimes had to be restrained but at other times he associated with the other patients and played games with them; he comprehended what was said to

him; he was coherent and relevant in his conversation, but his reasoning and judgment were limited; his memory was poor for recent events, but he appeared to take considerable interest in his surroundings, and was oriented in all spheres; his station was good but his gait was rather unsteady; there was noted a slight double cataract and double arcus senilis.

The autopsy revealed internal hemorrhagic pachymeningitis, shrinkage of the anterior convolutions but no other gross cerebral lesions, sclerosis of the aorta and of the cerebral basal vessels, pulmonary tuberculosis and pneumonia, and intestinal tuberculosis.

Case 20, white male, age 72 on admission and lived for 1 year and ½ month. He had been gradually losing his mental faculties for a year, and while in another institution he had been unable to find his bed and to take care of himself; he was disoriented and confused, and had no insight.

There was fine tremor of the tongue; pupils were slightly irregular in outline; the heart was somewhat enlarged; there was a coarse tremor of the right arm; the tendon reflexes could not be elicited; station and gait were greatly impaired. He was not oriented for time, place, or person; his memory for recent and remote events was very poor; emotionally he was apparently indifferent; there was no insight; no hallucinations or delusions were detected; the patient was quiet, feeble, and was agreeable and rather childish in his reaction; three or four days before his death he could not move his left arm and leg; the tongue was protuded slightly to the left; there was Babinski phenonema on the left; whether or not this attack was accompanied by a convulsive seizure is unknown.

The autopsy showed shrinkage of the frontal lobes; hemorrhage was found in the Rolandic region; in the left occipital lobe there was an old softening affecting this part; the heart valves were insufficient, and the heart enlarged; and parenchymatous nephritis.

Case 21, colored male, 65 years old at the time of admission and lived 3½ years subsequently.

The medical certificate stated that the patient had been normal until a few years previous to his commitment; he had bad memory and did not seem to remember anything; he was disoriented for time and place; he was restless, he talked senselessly; his reasoning was bad; and he appeared to be excited. The physical examination showed bronchitis, sclerotic superficial vessels, feeble heart sounds, no tremors, coördination was good; he had a poor grip; there was a slight arcus senilis with some visual impairment; no speech defect was observed. On admission he appeared to be senile; he was quiet and tractable; he showed some confusion and marked clouding of consciousness; he was disoriented; his attention could not be held; his memory was poor; his conversation was rambling and incoherent, and he usually answered incorrectly; no definite evidence of hallucinations or delusions was obtained, but he appeared to be suspicious that he was to be harmed in some manner; at one time, however, he said that colored people had been after him and almost scared him to death, but that white people came to his rescue; and later he also spoke of his farm and sheep having been stolen, etc.; at times he was restless and wandered around aimlessly, talking in a rambling manner; he became untidy in habits; he was very restless, and asked that he be permitted to go to his work.

The autopsy revealed atrophy of the anterior convolutions, sclerosis of the basal arteries, dilated heart, and chronic cystitis.

Case 22, white male, was 70 years of age on admission and lived for only 1 month subsequently.

His mother had been insane and confined in a hospital; otherwise, his family history was negative. The patient always had been a heavy drinker and occasionally he had a prolonged period of intoxication; he had been treated for dipsomania a number of times and six months prior to his entrance to the Hospital, following a lengthened drinking spree, he became quarrelsome and abusive; he thought other men were putting lice into his

bed and trying to injure his reputation in other ways; he threatened them; he believed he was in command and ordered those about him to do things for him; he heard voices of women and of his superior officers talking to him and he replied in a loud boisterous voice. Physically his muscles were of poor tone; his coördination was fair; his station and gait were unsteady, and his apparent delusion regarding lice may be explained by the fact that these vermin were actually found upon his body; he was neat and tidy in appearance; he was disoriented; he had no insight; his general memory was fair; there were auditory hallucinations of voices, but he would give little information about the voices, people, or what was said to him; he became irascible; swore frequently and fluently; he thought everything in the ward belonged to him; he gave orders to others to attend to the horses, etc.; and he conversed with imaginary people out of the window.

The autopsy showed that the convolutions were atrophied anteriorly; there were also atheroma of the aorta, cystic kidneys, interstitial nephritis, and cystitis.

Case 23, white male, was admitted at the age of 47 and lived 1 year and 7 months subsequently.

At the time of his admission no medical certificate was received and no previous family history was obtained; at first he was diagnosed as an unclassified psychosis, but on account of the pathological findings this was changed to arteriosclerotic dementia. On admission he appeared to have no use of his legs from his knees downward; he said he knew he was going to be killed and burning was the way to do it; he imagined that people were talking about him, and he heard them talking about it at night; he imagined he had plenty of money; he was noisy, untidy, occasionally talkative; he continually complained about everything, and he was very irritable; he was oriented; his memory was only fair; at times he was stupid; at one time he had a convulsion affecting the right side, after which he could not talk. Later he had a convulsion principally on the left which also affected the right.

At the autopsy it was found that he had bronchopneumonia, atheroma of the coronary artery and of the aorta, nephritis, and the convolutions of the anterior half of the brain were considerably shrunken.

Case 24, white male, admitted to the Hospital at the age of 55, and lived nearly 18 years subsequently. He had been admitted to a Soldiers' Home because of a paralysis and epileptic seizures. There he attempted suicide and was violent at times.

On entrance to the Hospital he was found to be deaf; he was depressed and had many morbid fancies. Later he was noted to be feeble, quiet, orderly; he did not answer intelligently; his mind wandered; he was indifferent to his surroundings; he was completely disoriented and showed no insight into his condition; at times he became very talkative and destructive, although most frequently he was quiet and comfortable; delusions of a pleasurable nature were evident at times, and later these gave way to delusions of persecution when he talked about the property and money which had been stolen from him; there was left hemiplegia with contractures; his gait was firm and rugged for one of his physical condition, but he dragged his left leg; the knee jerks were absent.

The autopsy showed slight enlargement of the heart, hypostatic congestion of the lungs, peritonitis, ulcerative cholecystitis, granular kidneys, marked shrinkage of the brain, but no areas of softening or of hemorrhage could be found to account for the hemiplegia.

Arteriosclerotic Dementia, Discussion

Only two of these cases (16 and 20) are strictly frontal cases. Two others (17 and 18) were cases in which there was a certain degree of atrophy of the cerebrum as a whole in addition to the marked frontal atrophy. The remaining five cases were those in which the atrophy extended over the whole anterior portions of the cerebrum. Case 22 was noted to be an alcoholic case, but the relation of alcoholism to the mental disorder is not clear, and the facts which have been recorded in the history

do not give any indication that alcohol played any great part in the production of the symptoms during his Hospital residence. We may believe, however, that it was a contributing factor. Case 24 appears at first sight from the history to be a case complicated with epilepsy, but no epileptiform convulsions occurred during the period of his Hospital residence, and it seems more likely that the convulsions were of a character which later resulted in the left hemiplegia, in other words, that they were seizures similar to an apoplexy. Before death all of these patients exhibited plain evidence of dementia. They were enfeebled, childish, indifferent, confused, were not affected by their surroundings to any extnet, and most often exhibited no insight into their mental condition, etc. The two cases which showed most evidence of mental enfeeblement (cases 17 and 18) were those in which some general atrophy was found to accompany the intensive frontal atrophies, and it is possible that the great degree of dementia in these cases is to be correlated with the extension of the atrophy to the posterior regions of the cerebrum, although the atrophy in the latter areas was not of great degree. The other seven cases did not differ to a great extent in the apparent degree of dementia which was present immediately preceding death, and in this respect there can be no great degree of correlation between the extent of the atrophy and the degree of the dementia.

The physical enfeeblement probably kept most of these patients less active than would have been normal for them, and the two patients who exhibited effects of paralysis, cases 16 and 24, were especially orderly and quiet most of the time. The physical enfeeblement did not, however, prevent these patients from becoming disturbed, noisy, restless and at times excited, and these states alternated with states of quiescence and even confusion, the only exception being that case 20 (with frontal atrophy) was uniformly apparently indifferent, inactive and agreeable. Lesions to account for the paralytic phenomena were not discovered, and it may be that part of the contractures in these patients were due to disuse and not to special paralysis. In other respects every one of these patients showed variations

from the normal motor ability, both in the presence of tremors and in their inaccurate, slow, and feeble voluntary movements. Patient 18, whose brain showed some general atrophy in addition to the marked atrophy in the frontal regions, also exhibited negativistic tendencies, and at other times he appeared to be purposelessly active. This patient, it will be noted, also showed other symptoms like those of the dementia precox group in that he was noted to laugh and to cry spasmodically and without apparent reason and to show perseveration. Both the similarities and the variations in these motor symptoms in these patients do not appear to be directly correlated with the distribution of the atrophies, for the unsteadiness and the tremors and the restlessness were found equally in those with frontal and in those with the more extensive atrophies.

The speech disturbances were not as pronounced as in the cases of general paralysis of the insane. At least four of these cases could talk readily, and also coherently and relevantly, and there was no difficulty in carrying on a conversation with them, if one did not approach their delusions or in the conversation make too much of a demand to strain their memory. There was in general none of the speech defects which are so commonly found in paretics, and when the patients would and could talk, their words were usually well-pronounced. Defective speech was, however, noted in some of them; patient 16 was observed to have a slight speech defect; patient 18 was also recorded at one time to have both sensory and motor aphasia, but the diagnosis of this condition is a very doubtful one, and should be accepted, if at all, with caution, for at that time the patient was in a very negativistic mood; patient 23 also showed a motor aphasia after a convulsive attack. Assuming the accuracy of the facts just mentioned, we may believe that these conditions were due to local cerebral injuries that were, however, not discovered at autopsy, and which may have been temporary or functional. Considering only the speech ability anterior to these accidents, we find that, with the exception of case 23, the speech of all the patients was similar; at times it was almost incessant, at other times they conversed voluntarily very little

but would answer questions, and at other times it was difficult to get any information from them. In other respects also their talk was similar; two patients with frontal and two patients with anterior atrophies talked at random, or incoherently, two other patients with frontal and two patients with anterior atrophies talked relevantly and could carry on conversations on minor matters. In these respects, therefore, we find with similar atrophies quite dissimilar characters of symptoms, and with dissimilar atrophies quite similar symptoms.

The affective conditions in these patients differed widely. Of the patients with frontal lesions three varied from an indifference to a general satisfied condition, but the fourth patient exhibited from time to time spasmodic laughing and crying, but whether this alternation was accompanied by the appropriate emotional states is not sure. This reaction has previously been compared with those of dementia precox patients, and in addition it may be said that it also resembles to a certain degree the similar symptom associated with lesions of the optic thalamus, especially in view of the association of hypoesthesia for temperature and pain. One of these patients (case 16), in speaking of his delusions of persecution, did not appear to react with appropriate emotional tone to them. The other five patients, those with anterior lesions, were depressed, suspicious, irascible, and quarrelsome, with more normal or more contented, or indifferent, intervening periods. Four of the latter group (patients 21, 22, 23, and 24) had corresponding delusions, and their affective states were associated with and corresponded with these other mental derangements. Patient 19, on the other hand, appeared hypochondriacal without apparent reason, for if he had delusions, they were not made evident (see below), and no hallucinations were discovered. Whether or not the greater frequency of particular types of emotional reactions and of special feelings is to be definitely correlated with the more extensive lesions can not be determined. That the general atrophy in cases 17 and 18, which it will be remembered was associated with a more marked degree of frontal atrophy, did not produce similar affective states is an indication that the special emotional con-

ditions, which superficially appear to be definitely associated with the anterior lesions, are better interpreted as chance occurrences, and that in a more extensive series they would probably not be found in as great proportion. This conclusion also appears more likely in view of the results which have been found in the other diseases which have been studied.

Only one-third of these cases gave evidence of hallucinations. These were cases 16, 22 and 23. Apparently case 16 had paresthesias in the fingers, for he complained that electric currents were sent through him so that they caused contractures of these parts. Regarding the other delusions of which he complained, viz., that he had been doped and that laudanum had been put into his beer, it is more difficult to judge whether these were purely ideational delusions or delusions due to paresthesias. The auditory hallucinations of patients 22 and 23 were very evident, but when patient 22 conversed with imaginary people outside of his window, it was not certain that the hallucinations were entirely auditory. The peculiar requests of patient 17 that his feet be amputated might be due to hallucinations, but this was not determined. Those patients who had sensory defects (patient 24 with deafness, patient 21 with visual defect, and patient 18 with hypoesthesia for smell, temperature and pain) did not apparently have hallucinations either in these fields or in others, nor did patient 20 in whose brain a small softening was discovered in the left occipital lobe. These facts do not indicate any definite relation between the mental conditions and the extent or degree of the cerebral atrophy.

There appears to be no more direct connection between the presence or the character of delusions and the atrophies of the anterior portions of the cerebrum. Patients 18 and 20 did not have delusions which were detected, and one of these (case 18) will be recalled as having had general as well as the well-marked frontal atrophy, the other being a simple frontal case. The other two patients with frontal atrophies did have delusions, some of the delusions in both being allied to hallucinatory phenomena, although a conclusion regarding this relation can not be stated with definiteness. The delusion of patient 16 that

he was still in active army service was probably a filling-out due to memory defects, but those regarding the loss of money, the action of electric currents and the presence of poison in his food are probably not due to this failure of memory, nor do the delusions of patient 17 regarding the money which he expected from England appear to be restrospective interpretations. It can not be said with certainty that patient 19 did or did not have delusions; the fact that he collected and attempted to fill his bed with trash indicates that he believed this to have some value or to have some relation to himself, but information on this point is totally lacking. The other four patients, all with anterior lesions, had delusions of persecution which with the exception of those of patient 21 alternated with mild delusions of grandeur.

All of these patients showed defective memory, and although it is almost impossible to determine the degree of the defect in the individual cases, the general reactions of patients 16, 17, 20 and 21 would lead to the conclusion that they were more abnormal in this respect than the other four cases. Four of these patients, it will be noted, are cases of frontal lesions, and the memory defects seem to be correlated with the degree of dementia, since it has already been mentioned that two of these (cases 17 and 18) were profoundly demented. The other two frontal cases, patients 16 and 20, were confused and bewildered and in their cases the memory defects may be either evidence of the confusion or the result or the concomitant of these conditions.

In marked contrast to the character of the memory is the orientation of the individual cases. Patients 17, 18, 20, 22, and 24 were completely disoriented; patient 16 was disoriented for time; and patient 21 was disoriented for time and places. The partial orientation of patients 16 and 21 is the more remarkable in view of their poor memory, and the good orientation of patients 19 and 23 is also to be contrasted with the degree of memory loss. The latter two cases, it will be recalled, are cases of anterior lesions, and this fact indicates that even with such extensive changes orientation for time and space may be retained.

Not much more can be said regarding the other mental pro-

cesses directly, although indirect information is obtainable in the case histories regarding the patients' ability to attend to impressions. In general, in these cases of arteriosclerotic dementia there remains considerable ability to attend to impressions, as has also been shown experimentally, and this ability appears to be independent of the memory disorder. Even though the patient was apparently very much demented or even confused, his attention could usually be obtained without difficulty, and this was noted especially for cases 16, 19, 20, 22, and 24. At times patient 23 appeared stupid, i.e., his attention could not be obtained, and although the attention of patient 21 could be obtained it could not be held. Whether or not we shall interpret the perseveration of patient 18 as "good" or "poor" attention can not be definitely settled; there is sufficient ground for either conclusion. The fact that with either frontal or anterior atrophies there may be good ability to attend is an argument against the supposition of an "attention function" for the frontal lobes, and the fact that the ease or difficulty of attracting the attention did not differ in accordance with the extent of the lesions which are here considered is evidence that direct correlation does not exist.

The variations in the mental processes which have here been considered permit the conclusion that neither the extent nor the severity of the atrophy of the anterior regions of the brain in arteriosclerotic dementia is directly correlated with the mental symptoms, and they also show that with similar atrophies dissimilar symptoms may be frequently encountered in different patients.

SENILE DEMENTIA, CLINICAL HISTORIES

Case 25, white male, aged 63 on admission, had been admitted in an obviously insane condition to a Soldiers' Home 4½ months previously, and lived 13 months subsequent to his admission to the Hospital. In the Soldiers' Home he was very restless, constantly wandered about, exhibited a defective memory, was careless of his personal appearance, and imagined that strangers were relatives who had been dead for years. Physically there were incontinence of urine, chronic cystitis, and marked tachycardia. No family or previous personal history could be obtained. Neurologically, there was tremor of the extended hands and protruded tongue, most of the tendon reflexes were exaggerated, coördination and station were good, the larger voluntary movements were fairly accurate and exact, but his handwriting was very shaky. He smiled and laughed spasmodically and without apparent reason, and without any apparent emotional accompaniment; he responded very poorly to the routine mental examination, forgot the questions which were asked, and showed little memory for his past life and what information he gave was apparently incomplete and inaccurate; he could not find his bed; he appeared to have no intelligent understanding; he had no insight into his condition; no hallucinations or delusions could be elicited; he was disoriented in all fields, and addressed patients and others by names not theirs, apparently thinking them friends or relations; he was so untidy that he had to be cared for in bed. Death was due to hypostatic pneumonia. In addition, the autopsy showed; chronic cystitis, nephritis, hemorrhagic enteritis, heart valves atheromatous, and circumscribed atrophy of the frontal lobes, but no other cerebral lesions. The clinical diagnosis was arteriosclerotic dementia, but the miscroscopical examination of the brain showed senile changes and did not confirm the clinical diagnosis, and the case is, therefore, included in this section.

Case 26, white male, had been noted as insane for 10 months previous to his admission at the age of 67; Hospital residence was 8 months. The signs of insanity noted on the medical certificate were: the patient wandered away from the ward, tore his clothing, he showed mental confusion, impairment of memory, occasional maniacal manifestations, incoherent talk, and was sleepless. The account he gave of his family and past life was incomplete but negative. Physically he had hypertrophied heart, superficial arteriosclerosis, slight arcus senilis, his hearing was impaired, the tendon reflexes were mostly exaggerated, and there was a tremor of extended fingers. He was kept in bed as much as possible, and at first was quiet and orderly, coöperating well. The mental examination showed a total lack of orientation, no insight except that at one time the patient said that if the questions had been asked a month previous he would have been able to answer them; his memory was very poor for recent and remote events; the only evidence of a delusion was his statement that he had been robbed of thousands of dollars; his talk was disconnected, but his speech was good. Later he became restless, fumbled with the bed clothing, was noisy, sang loudly, laughed and talked to himself, usually calling to horses, as if he were taking care of or driving them, and advising those around him to get out of the way or the horses would run over them; he pulled the bed clothing and his remarks were apparently due to ideas that he was driving; he took off his clothes and went about his room naked; apparently did not know how to put them on, for he was found putting his shirt over his legs. The autopsy showed shrinkage of the convolutions of the frontal lobes, but no other gross cerebral lesions; heart valves atheromatous, hypostatic congestion of the lungs, congestion of the stomach, intestines, liver, spleen and bladder, and slight fibrosis of the kidneys.

Case 27, white male, as an inmate of a Soldiers' Home was considered to be senile for nearly two years previous to his entrance to this Hospital at the age of 87, where he lived 2 years and 5 months.

The medical certificate stated that he was careless of his personal appearance, was childish, and, unless confined, wandered away and became lost. Physically he was very active for one of his age, and was in good general health. He showed, however, a beginning cataract in both eyes and was very deaf; there was sclerosis of the superficial arteries, the muscles were small (atrophied) and their force was slight, but movements were accurate and quick; there was a fine tremor of the extended hands; gait was normal and coördination was good. He was quite cheerful; he wandered about the wards in an aimless manner; he slept wherever he happened to sit down; he was untidy in habits; he lost his way on the ward; he was completely disoriented; he seldom spoke voluntarily, but answered cheerfully; he was inclined to be argumentative, especially regarding religious topics; he showed marked humor; occasionally he was excited and disagreeable and fought with other patients; he persisted in keeping his clothes on night and day; his memory was impaired, but he talked intelligently about historical events of which he had read; he spoke of $1,000 which he believed he had and which he wished to get so that he could go to his friends; this was the only near-delusion which was elicited. Death was due to cardiovascular and renal diseases; the autopsy also showed atrophy of the frontal convolutions, arteries sclerosed, emphysematous lungs and consolidation of the right lung, nutmeg liver.

Case 28, white male, was noted to have mental enfeeblement 4½ months previous to his admission at the age of 71; he lived 10½ months.

Neither family nor previous personal histories could be obtained on account of the patient's condition. There were no previous attacks known, and the first signs of mental enfeeblement became evident only a few months before his entrance to the Hospital. Alcoholism was given on the medical certificate as a probable cause of his condition, which was noted to be a "confusion." He believed himself to be on board a ship, persecuted, without his rights and often asked when he was to

be murdered; he also had hallucinations and threatened to commit suicide; he was quiet and unassuming. Neurologically, hearing was much impaired, a slight degree of arcus senilis was present, and the right pupil was smaller than the left; there were slight tremors of the fingers; skin sensations were somewhat impaired; all tendon reflexes were very much diminished with the exception of the biceps. He was disoriented for time, place, and persons; his memory for even the general events of his life was very uncertain; his remarks were almost unintelligible; but he appeared to have some insight, *i.e.*, he said he thought his mind was affected in some way; he took no account of the time or condition of things, he complained of the weather being snowy and cold when it was bright and warm, and he inquired why he was without shoes and clothes with the snow up to his knees; he denied having hallucinations; he also said he did not mind the snakes, but he was afraid of the big alligators lying flat with their eyes down; looking up at the ceiling he talked at imaginary people, and his remarks could not be understood, except that he swore and became very excited and sang and shouted. At one time he was found to have a twitching of the eyelids, and later the left and then the right arm were noted to be twitching (convulsion?); after this the Babinski phenomenon was present on the left, and he moved the left hand more than the right. The autopsy showed that the right hemisphere was shorter than the left, and there was slight shrinkage in the left frontal region; no other gross cerebral lesions were observed; the heart was dilated, with few atheromatous patches on the valve leaflets and on the aorta; pulmonary tuberculosis and hypostatic congestion; nephritis. The micoscopical examination revealed senile changes, although the primary clinical diagnosis had been arteriosclerotic dementia, and the case is therefore classed with the senile.

Case 29, colored male, his age on admission was 69, the duration of the mental disease was not given, but the patient had been in this Hospital for more than four years with a mental disturbance, the nature of which is not clear on account of lack

of clinical data, 13 years previously. He lived only 2 months subsequent to his second admission.

No family or personal history of value could be obtained, although his previous residence in the Hospital is known. The medical certificate stated that he exhibited delusions of wealth, was slovenly in his appearance, sang and danced for hours, but at times was irritable and quarrelled with others, and was unable to repeat test phrases. Syphilis was given as a probable cause of his condition, but a subsequent Wassermann test was negative. When received he complied with all requests willingly; he was extremely talkative, spoke well and intelligently; told how extensively he had traveled and recalled every place and event of importance, and his memory seemed to be accurate and exact; he spoke a few foreign phrases and thought he could talk several languages; he was bright and alert, was ready to talk when spoken to and ceased when requested and this without apparent offense; he was restless and wished to be doing something all the time; he denied having hallucinations, and his ideas of wealth were not out of proportion to his station, although previous to his admission he had peculiar ideas regarding some financial dealings with others; he jumped from one topic to another in his conversation; he was well oriented for place and persons, but not well for time; he appeared to have some insight into his condition for he said he was a "bit excited" on his admission and that his memory was not good. He said he had fallen from the seventh-story window thirty-four years previous to his admission and suffered from "concussion," and had been bothered with this more or less ever since. His feet were swollen and the skin over them was glazed, there was marked dyspnoea, radical arteriosclerosis, double arcus senilis, great emaciation, pulmonary tuberculosis . The autopsy showed slight frontal shrinkage, but no other cerebral lesions, valvular heart disease, atheromatous aorta, tubercular lungs, hypostatic pneumonia, nephritis. The miscroscopical examination showed marked senile changes in the cerebrum, especially in the frontal lobes although the clinical diagnosis was arteriosclerotic dementia (maniacal excitement).

Case 30, white male, was 65 at the time of admission and had exhibited mental disturbances for a year previous; he lived 13 years and 2½ months.

The medical certificate stated that he was admitted to a Soldiers' Home for various disabilities, including nervous prostration, at the age of 54, and he was placed in the insane part of the Home a few months previous to his admission to the Hospital, on account of "delusional insanity." It was noted that he was quiet and depressed; his memory was imperfect and his perceptions were impaired. On admission he appeared deeply depressed, he was quiet, and apparently he took no interest in his surroundings; evidences of delusions or of hallucinations were not found, but he constantly asked questions about words which he found in the books and papers he read, and figured a great deal on paper about them. At times he was cross and disagreeable to other patients and fought them, and was very noisy in the halls and had to be secluded. He appeared to have peculiar ideas about politics, taxation, the coinage of money and the money question, but it was difficult to understand what he meant; he drew maps of model towns and sent them to different people to have them adopted; he talked freely; he was tidy and cleanly. Later he took no interest in his surroundings and the peculiar ideas noted above became exaggerated and further elaborated; he also thought that the patients carried electricity around with them and shot it into him so that he was prevented from urinating, or that they hypnotized him and played witchcraft upon him; he was described at different times as being "completely disoriented" and "completely oriented," and as having a "good memory" and a "poor memory"; he stated that at night when he was alone and in bed he used to hear the voices of his enemies speaking on political matters; he wrote incoherently and almost incessantly. His gait was slow, there were no paralyses, the radial arteries were sclerosed, general tremors were present. Death was due to chronic bronchitis. The autopsy also showed: atrophy of the anterior cerebral lobes; atheromatous aortic valves, consolidation of the right lower lung; chronic cholecystitis; chronic inflammation of the liver, spleen, kidneys

and bladder. Three clinical diagnoses were made at different times: (1) undifferentiated psychosis (dementia); (2) paranoid state associated with arteriosclerosis; and (3) senile depression.

Case 31, white female; 77 years old at the time of admission; she lived 8 years and 3 months subsequently; the duration of the mental disease at the time of admission was not learned. No family or previous personal history, and no physical, including neurological, examination accompany the records, although on admission it was noted that her health and condition were good for one of her age. She was much confused and wandered around the ward in an aimless manner; she was free from delusions and hallucinations; she was forgetful and easily irritated, and childish and dependent in manner; she was tidy in habits. A year after her admission she had an epileptiform convulsion, which left her very much confused and reduced mentally but did not result in any paralysis. Epileptiform convulsions were present at irregular intervals, and previous and subsequent to these she became confused. Three years after her admission to the Hospital she was noted to have many delusions, especially those of great wealth, that the attending physician was her son, that she was going to will him a great deal of property; she often said she had just been visited by her relatives; she thought at times she was Queen Victoria, and at other times that the Queen was her best friend. She was noted to be picking imaginary objects from the floor and said she was gathering money there. She became hypochondriacal; her memory was defective; she lacked insight; there was poverty of ideas; she was disoriented; and her reasoning and judgment were impaired. For fifteen months before death she remained in bed helpless, totally indifferent to her surroundings; she never initiated conversation, and answered only in monosyllables. The autopsy showed that the convolutions of the anterior lobes were markedly shrunken; in addition there were sclerosis of the aorta, mitral and aortic valvular lesions, purulent bronchitis, interstitial nephritis and chronic cystitis.

Case 32, white male, admitted at the age of 74. The duration of his mental disturbance previous to entrance to the Hospital was not recorded. He died in 6 months.

This patient was admitted to a Soldiers' Home where he was found to have emphysema, spinal curvature and an old fracture of the ribs on the left side. While in that institution he had a slight fever and delirium which were thought to be due to gastritis, and following this he was noted to show evidence of dementia. He talked incoherently; he wandered around the ward and tried to get out; he was unable to find his bed, and constantly disturbed other patients by getting into their beds; he had "no conception of anything." Physically, he was poorly nourished, the mitral and aortic valves of the heart were slightly involved, there was sclerosis of the superficial vessels, there was bilateral arcus senilis; the pupils were unequal and irregular, the right gave the Argyll-Robertson reaction; there was tremor of the fingers; the tendon reflexes were not elicited; the Wassermann reaction with the blood serum was negative. He appeared to have no insight into his condition, but at one time he remarked there were things in his mind he knew were "not right"; emotionally he was indifferent; he was disoriented for time, place and persons; his memory was greatly impaired; he was unable to find his seat in the dining room or his bed at night; he was up and dressed and was fairly tidy; as a rule he was quiet and orderly, but later became very much confused, restless and untidy in habits. A right lobar pneumonia developed, from which the patient died; at the autopsy there were also found: cerebral convolutions atrophied anteriorly; calcification of the aortic and mitral valves; atheromatous arch of the aorta; tubercular scars in the left lung; liver and spleen somewhat cirrhotic; cortices of kidneys markedly thinned.

Case 33, white male, admitted at the age of 79, had been observed for over a year to show signs of mental impairment, and lived for 7½ years after admission.

The medical certificate stated that he had an uncontrollable temper, had hysterical attacks, delusions of persecution and loss

of memory. Physically there were: slight peripheral arteriosclerosis; hearing was very much diminished; the voluntary movements were normal in accuracy and rapidity, but they lacked force; the knee jerks were absent. The family and previous personal history was poor because the patient's memory for recent and remote events was defective and what was obtained showed nothing of interest or importance. The patient's expression was stupid, he was rather untidy, he appeared to be simple-minded and rather childish; usually he was good natured, happy and contented, but at times he was irritable and abusive; he was very industrious making baskets which he tried to sell; he talked and associated with the other patients in a normal manner; his memory for recent and remote events was not good, but, on the other hand, was not entirely absent; he conversed coherently, relevantly and freely; he was oriented, showed fairly good judgment, but exhibited no insight. Fluid accumulated in the abdomen and for this he was tapped twice, but died. At the autopsy the chief findings were: fifteen liters of fluid in the abdominal cavity; marked sclerosis of the abdominal aorta; peritonitis; sclerosis of the liver and kidney; and marked shrinkage of the anterior cerebral convolutions.

Case 34, white male, exhibited mental changes for nearly 3 years previous to his admission to the Hospital at the age of 80; and lived 1 year 2½ months subsequently.

The patient's family history and the account of his previous life were not well obtained, but what was learned was unimportant. The medical certificate reported him to be childish, restless, inclined to wander away and become lost. His general attitude was one of weakness, or weariness and fatigue; his gait was shuffling, and slow; he had impaired vision (beginning cataract); and defective speech. Neurologically he showed: arcus senilis; unequal pupils, the left failed to react to light; the knee jerks were diminished; there was a slight ankle clonus; there were tremors of the tongue, lips and face; a slight Romberg was present. He was noted to be harmless, agreeable, and coöperative;

he was absolutely disoriented; his memory was very poor both for recent and remote events; he was somewhat confused and was easily upset; emotionally he was unstable, and occasionally irritable, and possibly on the borderline of depression; he had nothing to say voluntarily; he preferred to be let alone and he sat in one corner and did not associate with the other patients; he appeared to have fair insight into his condition; his general comprehension, reasoning and judgment did not seem impaired when his mind was occupied with simple things; his mental associations were not very active; his ideation was limited in amount; he paid little or no attention to his environment. He became untidy, refused to answer questions and used profane, vulgar and abusive language to his questioners. The autopsy showed: slight atrophy of the anterior cerebral convolutions, but no other gross cerebral lesions; aorta and aortic valves atheromatous; bronchitis; pulmonary tubercular nobules; pulmonary emphysema; cirrhosis of the liver; fibrous spleen and kidney; the right adrenal contained an overgrowth and an hemorrhagic area.

Case 35, white male, has been mentally changed for a year previous to admission, at the age of 61. Hospital residence was 11 years and 2 months.

This patient was sent to the Hospital on account of delusions of "strange and impossible happenings" and hallucinations of hearing (fictitious voices) and of vision (mysterious objects). Physically he showed a dilated heart, bleeding hemorrhoids, and a right inguinal hernia. Neurologically his movements were deliberate, slow and rather weak; his coördination seemed somewhat impaired, although his gait was firm and steady; a slight fibrillary tremor of the tongue was observed; hearing was defective. He appeared to comprehend what was said to him, but was deliberate in answering; his memory was good, somewhat better for remote than for recent events; his reasoning and judgment appeared to be below par; he heard voices outside his door at night; he was mildly depressed but claimed to be fairly well satisfied with his surroundings (ex-

cept for his delusions); he also showed some irritability. Later he became more irritable, and at times he was ugly and insulting; he refused to answer questions; he was distrustful and suspicious, and exhibited delusions of persecution (he claimed that the physicians had him "wired," that they conspired to keep him in the Hospital, and hold him for robbery and mistreatment; and he refused to converse with them); he claimed that the patients ought to be sent to school and educated; he was oriented; he was tidy; he was usually quiet and orderly, but occasionally he became indignant, irritable and wrought up over his detention. Delusions of grandeur were added to those of persecution (he thought himself to be a very rich man and that the Government was robbing him of thousands of dollars daily); his memory became poor; he was disoriented for time; when talking with the physicians, regarding whom he had delusions, he became so emotional that his voice trembled; he refused to answer questions regarding his condition; he was usually quiet, orderly and well-behaved except when approached by one regarding whom he had delusions; later he believed the attendants were putting poison into his food and drinks, trying to shave him against his will and injure him in other ways; insight into his condition was lacking. Death was due to cardiovascular and renal diseases; the autopsy also showed shrinkage of the cerebral convolutions over the anterior two-thirds and atheromatous cerebral vessels.

Case 36, colored female; the duration of the mental disease at the time of admission was not stated in the medical certificate; she lived in the Hospital 7 years and 5 months.

The age of this patient was unknown, but she was undoubtedly old at the time she was admitted from the Alms House; there she had been observed to be "maniacal," *i.e.,* very much excited; she could not answer questions intelligently and at times showed that she had delusions that people were after her; she was noisy, especially at night. Her facial expression was one of apathy; her gait was slow and feeble; the physical examination showed nothing abnormal; neurologically she showed fine tremors of

the extremities, sight and hearing were defective. She was somewhat disoriented and there was some clouding of consciousness; she did not appear to appreciate her surroundings; her memory for remote events was fair, but poor for recent events; in talking she lapsed into incoherency, goal ideas were lost; her reasoning and judgment were impaired; she thought she could talk with the Lord, and she became religiously excited at times, but as a rule she sat quietly in the ward, taking no interest; she was tidy in habits. She exhibited the signs of gradual mental enfeeblement; memory became practically a blank, and she became untidy in habits; she did not want to be interfered with by the nurses, and occasionally she showed a rather cross and irritable disposition; she sat in one chair with an apron over her head for hours; she never spoke unless spoken to and then always complained of being burned up by fire; the reason for covering her head could not be learned. Death was due to pulmonary hypostasis and hemorrhagic cystitic; the autopsy showed in addition generalized arteriosclerosis, cardiac atrophy, chronic diffuse nephritis and atrophy of the anterior two-thirds of the cerebral convolutions.

Case 37, white male, had been mentally deranged for 2 years previous to his admission at the age of 74; he lived in the Hospital 3 years and 2 months.

The family history was negative. At the age of 43, as a veteran of the Civil War, he was admitted to a Soldiers' Home, for "physical disability and mental incapacity." The physical disability was a contusion of the right shoulder; the character of the mental incapacity was not noted, but could not have been a marked mental change since the patient was able to take care of himself and was permitted to go at will. Twenty-four years later, at the age of 67, he was noted to have "impaired cerebration," but this term is not defined; six years subsequently he was noted to be senile; to have impaired cerebration and delusions of persecution (he thought he was to be hanged for misdemeanors of which he was not guilty) ; he was inclined to be talkative, but his conversation was disconnected; there was inability to concen-

trate his thoughts; he showed impaired judgment and reasoning. On one occasion a rope, carefully and securely fixed, was found in his locker, although it is not known that he had attempted or planned suicide. Physically he was quite active for his age, and his physical condition good with the exception of difficulty of hearing and right inguinal hernia. On admission he was restless and confused; he showed no interest in his surroundings; he was untidy in appearance, but tidy in habits; it was difficult to make him understand, and he failed to answer questions; no delusions could be elicited, although he appeared to be apprehensive and afraid that any one who approached him would do him harm; his consciousness was clouded; he was disoriented for time and place; his memory and intellect were very much impaired; his emotional tone was one of indifference. Soon he became untidy in habits, and there remained to him only a remnant of his former knowledge; he was kept in bed; he took no interest in his surroundings; when approached and questioned he cried and whined pitifully, he volunteered no information and he answered few questions; he was entirely disoriented; he seemed to remember the events of his childhood but none of recent date; no delusions or hallucinations could be elicited. He was restless and pulled and rearranged his bed clothing frequently and resisted attempts to help him. Death was due to bronchopneumonia. The autopsy showed marked shrinkage of the frontoparietal convolutions.

Case 38, white male, was admitted to the Hospital at the age of 72; his mental disturbance began 2 months previous to, and he lived only 1 month after his admission.

For two months previous to admission the patient was childish, forgetful, disoriental, and had a depression. His family history, as far as it could be ascertained, was negative. Physically he showed slightly enlarged heart, double arcus senilis, and defective hearing; Wassermann reaction with the blood serum was negative; albumin and casts were found in the urine. Neurologically he showed: sluggish accommodation reactions, and irregular pupils; deep reflexes diminished; slight Romberg sign; gait was very feeble; muscles wasted and atrophic; voluntary move-

ments feeble; irregular tremors of the fingers. Mentally he said he was sad, but usually he appeared to be indifferent; he had a poor memory; he was not oriented for persons, and only partially for time and place; insight was lacking; no hallucinations or delusions were elicited; his speech was good. The patient developed diarrhoea and died from exhaustion; the autopsy revealed no arteriosclerosis; the cerebral convolutions were shrunken over the frontal lobes and the posterior portions of the parietal lobes, but section of the brain showed no other changes; aortic atheroma; pulmonary tuberculosis; and parenchymatous nephritis.

Senile Dementia, Discussion

These fourteen cases are not entirely alike as far as lesions are concerned, and, it will be noted, some diagnostic questions have been raised regarding some of them. Case 28 has been noted as being a possible alcoholic psychosis, and some of the hallucinations which this patient had are suggestive of the alcoholic delirium. Patients 29, 30, and 37 were also considered at one time to be rather doubtful. Patient 29 was admitted to the Hospital for the first time at the age of 56, was subsequently discharged, but readmitted at the age of 69. Patient 30, on the other hand, had been noted to have had "nervous prostration" eleven years previous to his admission to the Hospital, but the symptoms which he exhibited at that time were not recorded, and it is impossible to determine the nature of the condition. Since the term "nervous prostration" is so inaccurately used by general practitioners, it is difficult to be certain that the patient exhibited anything more than a disinclination for mental and physical work. Patient 27 also had been noted as exhibiting "mental incapacity" thirty-one years previous to his admission to the Hospital, but, as has been noted in the case history, this was probably a very general term, and it may have been only a means of having him enrolled as an inmate of the Soldiers' Home in which he spent these years. Patient 31 had epileptiform convulsions, but no previous history of disturbances of this nature was obtained, and it is likely that these convulsive seizures were due to the degenerative cerebral conditions which mentally resulted in the dementia.

Regarding the cerebral conditions, similar variations are noted. Patient 28 exhibited what appeared to be an unilateral atrophy on the left side of the cerebrum. The description of the atrophy in case 37 is probably to be taken to be the equivalent of that which has been noted in cases 35 and 36, namely, that it covered the frontal, central and parietal regions of the brain, in this way taking in approximately two-thirds of the convexity. The brain of patient 38, like that of patient 28, also showed rather circumscribed atrophies, and it has been noted that these were in the posterior parietal lobes as well as in the frontal lobes. This case is added for the purpose of comparison with those cases which are strictly frontal atrophies, and for the purpose of comparison with the extensive lesions which were found in cases 35, 36, and 37. The degree of atrophy in these cases was varied, cases 28, 29, and 34 exhibiting only a slight amount of atrophy while cases 31 and 33 showed a marked degree of shrinkage.

In general the mentality of these patients did not greatly differ. All showed a considerable degree of dementia. They had little intelligence or understanding of what went on about them; they were at times unable to answer questions; they had become childish, slovenly in appearance, and they wandered around the wards aimlessly. At the same time, they were mostly harmless and usually quiet, agreeable, and sometimes apparently stupid, but at times they became restless and irritated. Patient 34, who exhibited only a slight degree of atrophy of the frontal regions, was apparently as demented as any of the other cases, and patients 28 and 29, whose brains were also noted to exhibited only slight atrophies, were at the same time considerably demented. On the other hand, the marked degree of cerebral atrophy which was found in the brains of patients 31 and 33 did not appear to bring about any greater degree of dementia or loss of mentality than in the other cases. These two patients were confused or wandered away, or were stupid, simple-minded or childish, but in these respects they were not any less mentally active or mentally endowed than patient 25, who was noted to exhibit "no intelligent understanding," or than patient 26, who was quiet, confused, or than patient 27, who was childish and wandered

away. The relation of the general mental condition of dementia to the frontal, or to the distributed anterior, or to the even more extensive frontal-parietal atrophies is not a definite one, and it is apparent that in these cases, as well as in those which have previously been considered, the relation of the degree of atrophy to the degree of dementia is not simple.

Most of these patients exhibited rather marked degrees of motor disorder. Tremors of the hands, tongue, face, or fingers were found in nine of these patients, and it is of interest to note that with the exception of patient 29 the frontal cases showed these disturbances as much as those cases in which the atrophies extended beyond the limits of the frontal lobes. In fact, those patients whose brains were found to have the more extensive atrophies (patients 31, 33 and 37) did not show motor disturbances of this character. Patients 27, 29, 33, and 37 were active for individuals of their age, and although in connection with general muscular atrophy they usually showed a slight amount of force in their movements, their movements were accurate and quick. It will be seen that some of these patients were those in which the precentral region was also included in the atrophic zone. In these cases, aside from the tremors, the five patients with frontal atrophies (including case 38) were apparently motorially more capable than those patients with the more extensive atrophies. This, however, is only true in a general way. The cases showed such extensive divergences in this particaular that they can not be considered to be correlated with any special degree or with any special extent of the pathological conditions of cerebral atrophy.

The conversation of most of these patients was disconnected and frequently incoherent. Their remarks were often almost unintelligible. They answered questions in an irrelevant manner, sometimes slowly or, as it has been described, deliberately, and at times they refused to answer or failed to answer at all. These variations from the normal activity were found in practically all these fourteen cases, although there is one exception, viz., patient 38, who not only answered properly and intelligently, but his speech, *i.e.*, his enunciation was good. In the case of speech as

distinguished from conversation, it was found that many of these cases exhibited no specific alterations, although patient 29 has been described as having been unable to repeat test phrases, and patient 34 was noted to exhibit defective speech.

The emotional tone of patients 27 and 28 is not specifically mentioned, and conclusions regarding their conditions in this respect must be drawn from the other facts in the case histories. We may conclude from the general accounts that patient 27 was usually cheerful, but at times, on account of his delusions, apparently depressed, and, as has been noted in the account given above, he was occasionally excited, disagreeable and pugnacious. The hallucinations which were evident in patient 28 and the delusions which he gave voice to did not appear to bring about very marked emotional reactions, although he was excited at times. As a rule, the other patients were usually indifferent; they were quiet; some of them were stupid, childish, and as may be concluded from their general mental symptoms, they ranged in their affective states from indifference to excitability, or to feelings of well-being, or to a depression or sadness. Patient 25 was perhaps the only one who exhibited no evident emotional reaction, although it should be remarked that he laughed and smiled spasmodically. Externally he appeared to be emotionally labile, but in reality he had no apparent affective concomitant with these reactions. The relation of these emotional conditions to the extents and degrees of atrophy is not apparent. Those patients with frontal lesions appeared to be as much affected as those with the more extensive lesions, and the condition of marked atrophy in patients 31 and 33, it will be noted, did not give rise to any special degree or character of affective phenomena.

Eight of these patients showed at no time any evidence of hallucinations. The other six patients did have hallucinations, with a possible exception of patient 26. The latter patient, as the case history shows, laughed and talked to himself and had delusions of driving horses or of calling to them, and, like patient 22, he was found calling to horses as if he were taking care of or driving them. Whether these symptoms should be interpreted to be entirely delusionary or to be partially hallucinatory, as if he

had the particular sensations in the hands and arms of driving or of rubbing down the horses, or of the visual experiences of seeing the horses, cannot be determined. It appears probable, however, that the delusion of his taking care of and driving these animals was due to the presence of hallucinations as much as to anything else. The hallucinations of patient 28 are much like those of the alcoholic delirium, as has been noted above. The hallucinations of alligators and snakes were especially like those which a patient with delirium tremens experiences, and the evident disorientation regarding the seasons when he complained of the cold weather, with snow on the ground, when in reality it was bright and warm, and when he complained of his being without shoes and clothing with the snow up to his knees, appeared to be much more like the paresthesias which an alcoholic might have. This apparent delusion, or disorientation for time, appeared, therefore, to be much more like a tactual paresthesia, or to be dependent upon such a condition, although it is not certain that we can exclude the visual element. In the expression of her delusions patient 36 also gave evidence that she had paresthesias, for it will be remembered that she complained of being burned up by fire. It is also possible that her delusion regarding her ability to talk with the Lord may have had as a basis the presence of auditory hallucinations of voices. Patients 30 and 31 at the time of their entrance to the Hospital were noted to be free from hallucinations, but at a later date both of these patients gave evidence of the presence of these abnormalities. Patient 30 complained that he heard voices at night. At the same time it should be remembered that he also complained that electricity had been used upon him, which had prevented his urination. Patient 31 was found trying to pick imaginary objects from the floor. Whether or not this reaction was due to a visual hallucination or to a combination of visual and tactile hallucinations was not determined. The delusion of patient 30 regarding the action of electricity was undoubtedly of an hallucinatory nature, as has been mentioned, the particular hallucination being of the organic type. It is of interest in this connection to note that these patients who exhibited hallucinations showed these abnormalities more frequently in the field of the skin sensations than

in other fields. From what we know regarding the functions of the postcentral areas of the brain it might be expected that this kind of hallucination would be more common in those patients who exhibited atrophy in the parietal region, viz., patients 35, 36, and 37, but of these three patients only one had hallucinations of this character. This woman complained of being burned up by fire. Patients 26 and 28, whose brains were only atrophied in the frontal lobes, also had the same kind of delusions, apparently based upon tactile or organic hallucinations. From these facts it appears that the hallucinations in these cases are not directly connected with the degree or the extent of the atrophies which have been recorded.

Three of the patients were entirely free from delusions of any kind. Two others, patients 25 and 37, were somewhat doubtful, although it appears that patient 25 in mistaking individuals and calling them by names not their own was suffering from a defect of memory or of orientation for persons, and did not have, primarily, a delusion. It is impossible in the case of patient 37 to determine whether the ideas of persecution which he spoke of were or were not delusions. At any rate, they were not particularly evident, although it should be remembered that he frequently appeared to be apprehensive, as if some harm would happen to him or as if he were being persecuted. Delusions of persecution were also found in patients 26, 28, 30, 33, 35, and 36. These gave way to delusions of grandeur or of exaltation in the case of patient 35, and perhaps also in the case of patient 36. Delusions of grandeur were also given expression by patients 27, 29, and 31. Although patients 25, 30, and 31 did not show any evidence of the presence of delusions at the time of their admission to the institution, at later dates delusions, of which mention has been made in the individual case histories, were in evidence. The association of delusions with lesions of the frontal region, in view of the lack of these abnormalities in cases 32, 34, and 38, and possibly also 37 and 25, can not be said to be demonstrated by these series of cases. If we believe that the *"Personenverkennung"* of patient 25 to be a real delusion, we can conclude that all of the simple frontal cases exhibited delusions. Opposed to this,

however, is the fact that the extension of the atrophies beyond the frontal region in the other nine cases did not always result in delusions. Case 38 is particularly interesting in this connection because the frontal region was undoubtedly atrophied, and added to this atrophy there was an atrophy of the posterior portion of the parietal region. If frontal lesions in themselves were especially allied to the delusion formation, it is to be expected that the more extensive atrophy would have been accompanied by this mental condition. Such, however, was not found. In these cases, therefore, delusions appear not to be directly associated with a particular location or a particular degree of atrophy.

Patient 29, who showed only a slight frontal atrophy, exhibited an accurate and exact memory. Patient 35, especially during his early Hospital residence, was also found to have a good memory, and although patient 30 was noted as having an imperfect memory at the time of his admission, it will be noted that according to the case history his memory varied from "good" to "poor" during his later Hospital residence. At times he appeared to have a very good grasp upon his surroundings, to know the events of his past life as well as other events, and at other times he did not appear to remember these things. In the other cases memory was poor. In the cases of patients 36 and 37 memory for remote events, especially those of their childhood, was fair, but for more recent occurrences memory was bad. When we consider these phenomena in connection with the extent and degree of the atrophies which the brains of these patients exhibited, there appears to be no correlation whatsoever.

Case 33 was the only patient who was completely oriented, and this is particularly noticeable in view of the extent and degree of atrophy in his brain. Nine of the other cases were completely disoriented for time, for place, and for persons. Patient 29, with a slight frontal atrophy, was disoriented for time, and similarly patient 35, while patient 38 was disoriented for persons and only partially disoriented for time and for place. Patient 30 exhibited the same kind of fluctuation regarding this mental function as he did for memory, in that at times he appeared to

be completely disoriented, to know nothing of time or of place or of persons, and again to have an excellent grasp upon these things. In this way there appeared to be fluctuations in his mental condition, and these have, as far as can be determined, no direct correspondence with the cerebral lesions in his case. The abnormalities in this field do not apparently depend upon the character or degree of the atrophies, the opposing evidence shown in case 33 alone being such as would prevent any definite statement regarding a relation.

Nine of these patients lacked insight. One, patient 34, had fair insight into his condition, whereas the other four cases had what might be termed partial insight in that, in answers to questions, they gave evidence that they recognized that something was wrong with them. They were incapable of making any kind of analysis, and in at least some of the cases it is not certain that their remarks should be interpreted as evidence of insight. Thus, patient 26 appeared to have no insight into his condition except that he remarked at one time that if the questions had been asked him a month previously, he would have been able to answer them. Patients 28 and 32 were more evidently in a condition in which they appreciated that something was wrong with their minds, for both admitted that there were "things in their minds which were not right," and that their minds were affected in some manner. There appears to be some relation between the degree of brain shrinkage and general insight in that in every case in which there was a slight degree of atrophy insight was present, partially at least. Insight, however, as related to the extent of atrophy, does not appear to have much correlation, although of the five frontal cases three did exhibit some insight into their condition, while of the anterior atrophies only two exhibited insight, and of the four remaining cases none exhibited insight in any degree.

Some of the other abnormalities which have been recorded in the case histories may have relations to the sensory defects which were present in these patients, although this is not apparent. Apprehensiveness, or delusions, or feelings of depression or apathy may be due to the presence of defects of hearing,

which abnormality was found in eight of these cases, and which in otherwise normal individuals appears at times to be associated with suspiciousness and allied affective states. It will be remembered that patient 28 had some impairment of the skin sensations, and it is possible that his hallucinations and his delusions of disorientation, snow on the ground, etc., which have been described in a previous paragraph, may have been due to the hypoesthesia for skin sensations. At the same time it should be recalled that patient 27 and patient 34 exhibited signs of beginning cataract, but these visual defects did not bring about any types of visual hallucinations or delusions. It is unfortunate that the "impairment of perception" noted in patient 30 is not more fully described, for it is possible that there were, in his case, sensory abnormalities which may have had certain relations with the delusions and hallucinations of which this patient gave evidence. The impairment of skin sensations in patient 28 is not correlated with atrophy of the postcentral region, since it will be remembered that this patient exhibited only a slight atrophy in one hemisphere.

When we deal with these patients as a group, we find, as in the other psychoses, extensive atrophies associated with some mental conditions quite similar to those found in the patients with the less extensive atrophies. In general it may be said that the exaggerated atrophies have given rise to no more prominent symptoms than the milder or slight degrees of atrophy which were recorded as being present in the brains of three of these patients.

SUMMARY

Although all the cases which have been studied exhibited atrophies which always included the frontal cerebral convolutions, and some also included atrophies of the neighboring central and parietal portions of the cerebrum, no one symptom was found to be constant, with the possible exception of that complex condition which is called dementia. It is also to be noted that although the degree of atrophy varied from "slight" to "marked" no one symptom or degree of symptom was found to correspond with these cerebral changes. In general, therefore, we may say that there is no apparent correlation between the extent or the degree of atrophy and the general mental condition. Those individuals who exhibited only frontal atrophies at times showed as much dementia as those in which the atrophy was more extensive, and many of the cases in which the atrophy was of a slight nature were also as demented as those in which the atrophy was noted to be great.

Nor does there appear to be any correlation between the form of the disease in the individual groups and the extent or the degree of the cerebral atrophy. It is true that more of the dementia precox group with anterior atrophies were catatonic in nature and that more of the frontal cases appeared to be rather paranoid. On the other hand, both with frontal and anterior atrophies, sufficient cases with other forms of the disease were observed, and it seems certain that the extent of the atrophy is not the determining element in the production of the collection of symptoms which give warrant for the diagnosis of the "form" of the disease. For the arteriosclerotic, senile and paretic groups of cases a similar statement may be made. In none of these collections of cases did there appear to be any definite correlation between the degree of the atrophy and the special form of the disease, and in the special discussions of the individual groups of cases it has been stated that no

correlation between the degree of dementia (paretic, arteriosclerotic, senile, or precox) and the extent or the degree of atrophy was present.

A similar statement holds true for the probability of correlation between degrees of atrophy and the general behavior of the cases which have been considered. Such behavior as the care of the person and the relations of the individual to his environment and to the other patients did not vary in accordance with the location or the amount of the cerebral changes.

On the motor side, similarly, we find no definite correlation existing. In the dementia precox group those with atrophies extending beyond the frontal regions differed in no respect from those in which the atrophy was confined to the less extensive area. The paretics with simple frontal lesions were perhaps more active than those with the lesions extending over the central convolutions and into the parietal lobe, but the cases of senile dementia and those with arteriosclerosis cerebralis were about equal in this respect. The motor phenomena which are found associated in these cases with atrophies do not appear to be correlated with the degree of the atrophy. In none of these collections of cases was it found that the motor phenomena differed to any extent when the degree of atrophy was great from those in which the atrophy was slight.

The emotional or affective states of these patients varied considerably. No one fact stands out particularly to indicate any possible relation between the affective states of these patients and the extent or the degree of the cerebral atrophy, and in fact in this case the conclusion can also be drawn that there is no correlation of this character.

The variety of the hallucinations which have been recorded and the fact that these symptoms were not uniformly present in those with similar atrophies does not indicate any definite relation between the appearance of hallucinations and the atrophies with which we dealt. It would appear that in the dementia precox group the more extensive atrophies were more frequently associated with the presence of hallucinations,

but such a conclusion can not be made regarding the groups of paretic, senile and arteriosclerotic dements.

Nor do the delusions appear to be correlated with the extent or degree of atrophies. Delusions appear to be as relatively frequent in case of frontal atrophy as in those cases in which the atrophy is more extensive, and in this connection it is of interest to note that with the marked changes in the frontal lobes which have been noted in connection with a number of the cases delusions were not always found. From the data which were available to him, Southard has concluded that frontal lesions are more frequently accompanied by delusions, but in the present series sufficient cases in which no delusions were present have been observed, in which frontal atrophies were present, either simple, or combined with those of the central convolutions and at times with those of the parietal region. It is worthy of note that of the dementia precox group there were three; of the paretics, one; of the arteriosclerotics, three; and of the senile, five; a total of twelve cases, in which no evidences of delusions was discovered, although in all of these cases an atrophy of the frontal lobes was discovered at the time of the autopsy. As a possible definite relation with the cerebral lesions it may be said that most of the patients exhibited poor memory and poor orientation. On the other hand, the accuracy of memory of some of the patients was remarkable in view of the degree of dementia which was noted to be present, and in some of the cases the orientation ability was also remarkable in view of the extensive cerebral changes which were found.

Summing up this portion we may definitely say that there has been discovered in the present collection of 38 cases no definite relation between (A) the degree of mentality, or lack of mentality, the character of the disease, the motor and affective states, the presence of delusions or hallucinations, memory or orientation ability, and (B) the degree and extent of the cerebral atrophies.

GENERAL DISCUSSION

On the assumption that similar portions of the brain in different individuals have like functions, we should expect that corresponding lesions would give rise to similar symptoms. That, however, the symptoms differ even though the lesions be similar is shown by the study of the case histories which have been summarized in previous sections. In addition, it requires no extensive acquaintance with the clinical contributions of neurologists to recognize that cerebral lesions other than atrophies do not always result in similar mental abnormalities, or symptoms. Nor does it require any great amount of critical ability to reach the conclusion that numerous facts which have been recorded in clinical neurological literature do not always warrant simple explanations of the relation of cerebral activities and and mental phenomena. It is apparent that the variations in the symptoms which accompany similar cerebral lesions in different individuals have often been minimized and sometimes disregarded, perhaps for the sake of simplicity of explanation.

In some few cases, on the other hand, the variations in the results of physiological investigations of stimulation and extirpation and the differences in the clinical symptoms accompanying similar cerebral lesions have also led to numerous polemics. Dissimilar symptoms have been shamefully taken from their settings, estimated too highly and extravagantly emphasized by those who controverted the quasi-phrenological views of cerebral function.

There is, however, no good reason either for disregarding the dissimilarities of symptoms accompanying cerebral lesions or for concluding that these dissimilarities demonstrate that all parts of the brain act in the same manner and that there are no cerebral "centers." The fact of dissimilarity must be accepted and brought into relation with the other facts which are known regarding cerebral function and control.

It has already been pointed out that in physical diseases the symptoms of individuals may differ to a considerable extent, and also that lesions in widely separated portions of the brain

may give rise to different symptoms in different individuals. Many neurologists now recognize the latter fact, and von Monakow in particular has been insisting that this fact is of primary importance for deducing the functions and functional connections of the cerebrum. The similarity of symptoms accompanying different lesions is readily understood if we conceive of the nervous system, and especially the cerebrum, as a collection of cells with connections, the function of which is fixed largely because of the intercommunicating connections. The individual cell has its own function, but in the production or control of any of the cerebrally produced or controlled processes in other parts of the body, or of mental states, it is the serial or grouped activities of nerve cells which must be dealt with. When this view is taken it becomes clear why dissimilar lesions may produce similar symptoms. A break at any part of the chain will prevent the normal function, which is serial.

It is now recognized that widely separated areas are always involved even when only a very small portion of the cerebral cortex is injured or destroyed. The destruction of some portions may immediately produce perfectly obvious defects or exaggerations of normal behavior, while the destruction of other portions may give rise to effects which are not immediate or obvious. The effects of the latter lesions are sometimes to be discovered only indirectly and at other times they are, as von Monakow points out, of a "latent nature and only become manifest when there is added to the primary operation (*i.e.,* a lesion) a second operation upon, or a pathological process in, another region of the cortex."[5]

The present series of facts are, however, different from those with which von Monakow and others have dealt. They are the reverse conditions, and they are not readily understandable on the hypothesis which von Monakow has set forth to explain the similarity of symptoms with dissimilar lesions. In connection with these studies of frontal and anterior atrophies it should be pointed out that dissimilarities of symptoms from

[5] Monakow, C. von. Theoretische Betrachtungen über die Lokalisation im Zentralnervensystem, insbesonder im Grosshirn. *Ergebnisse der Physiol.,* 1913, 13, 206-278.

frontal lesions have not infrequently been the cause of much discussion and recrimination. Thus, the clinical findings which have been recorded at different times by different investigators whose material (patients) was not exactly the same have given rise to the hypothesis that the frontal lobes are (1) intellectual centers, (2) centers for emotional states, (3) centers for inhibition, and (4) motor centers. Without attempting at the present time to advance a more general hypothesis than those already suggested, it may be said that the clinical facts are not mutually exclusive and that all can be brought together under one heading which gives a suggestion for the explanation of the functions of the frontal lobes.

Facts of an experimental nature are also at hand to show that the definiteness of control by the motor (precentral) cortex is not as great as that which is usually assumed to be the case. These will be dealt with in the second part of this monograph. All of the facts indicate that we must conclude that the action of the cerebrum is a diffuse activity, and an activity which varies from individual to individual, and in the same individual from time to time. A full discussion of this hypothesis will appear in connection with the study of the variability of control from the motor cortex. At the present time it may be mentioned that it seems most satisfactory to consider the cerebrum as a labile organ or, in other words, as a series of cells with numerous possibilities of connections. The number of connections makes possible a variety of activities, since at one time a cell may act through its main axonal connection upon a second cell, and at another time through its collateral connections it may act upon a third or fourth cell. Probably the cerebral cells do not always discharge, or influence other cells, in the same manner. We should, therefore, not hold to a belief in a definiteness and simplicity of physiological connections, but rather to a manifoldness of connections, any one or more of which may be used or not used at one time. The use, non-use, or disuse of any one of the possible paths at different times will produce differences in behavior, and similar lesions of cells may, therefore produce different symptoms in accordance with the normal (to the individual) connections which have thus been interfered with.

II

VARIATIONS IN DISTRIBUTION OF THE MOTOR CENTERS

INTRODUCTION

The earliest positive results of the electrical stimulation of the cortex were obtained by Fritsch and Hitzig, and at that time and for a number of years the movements obtained on stimulation of the cerebral cortex were described in terms such as to suggest that the resulting movements were definite movements of individual muscles. Subsequently attempts were made to determine the cortical localization or representation of individual muscles or muscle groups, but it was amply demonstrated by more recent experiments (especially those of Sherrington and Grünbaum (**6**) that all the movements which result from cortical stimulation are complex movements. These are "movements" in a particular sense of the word and not simply contractions of muscles. They are movements which are best described as behavior phenomena, not only movements of flexion but movements of grasping, not simply extension movements but movements of repulsion or thrusting away. In many cases the complex activities of the associated muscular contractions can best, and at times can only, be described in terms of such behavior activities.

From time to time in attempting to demonstrate the motor control by the cortex by stimulating the so-called motor centers difficulty was experienced by me with some animals in obtaining special reactions of parts which appeared to be readily obtainable in other animals.[1] These variations in the stimulability or in the control from the cortex were at first, on account of the

[1] Compare also Sherrington's remark: "In the cat it is in my experience quite infrequent to obtain primary extension of the crossed elbow from the cortex. Flexion is readily and regularly obtained." *Integrative Action of the Nervous System,* 1906, page 293.

definiteness with which most previous results have usually been described, believed by me to be due to defects in technic or to variations in the excitability of different cortical regions in different animals under anæsthesia. A careful examination of the literature devoted to the experimental investigation of the motor cortex in animals indicated, however, that notwithstanding the supposed definiteness there was considerable variation in the location of special areas in different animals. This variation appeared to depend, to some extent at least, upon the varying configurations of the fissures and consequently the varying positions of the collections of cells governing particular movements. On the other hand, it also appeared possible that some of these variations might be variations of a primary nature, *i.e.,* not due to the adventitious condition of anæsthesia or other similar circumstances. In fact, the careful examination of published work on the motor cortex, especially that of the Vogts (**11**), shows that the location of the individual cerebral areas controlling certain of the small bodily segments is not as anatomically (spatially) definite as has been supposed. Such as least was the suggestion that was received when the results of previous investigations were compared. Accurate determinations of the variations of previous investigations were not found to be practical, both on account of the differences in method that individual investigations had employed and their methods of recording results and also on account of the different species of animals on which the tests were made.

Because of these considerations, it was thought advisable to attempt comparisons of the results of the stimulation of the brains of a number of animals of the same species in order to determine how much, if any, variation there is in the relation of parts of the precentral cortex to the control of different bodily segments. It appeared possible that in this area of the brain there are variations of an individual nature, not explainable on the ground of variations in fissural configurations. The animals chosen for the present investigation were monkeys, *macacus rhesus,* five of which gave results of value.

METHODS

An animal was driven from its cage into a large burlap sack and completely anæsthetized. It was then transferred to the operating board and kept under the anæsthetic during the whole period of the experiment. The A.C.E. mixture was used in all of the experiments. At the time the movements of the animal were to be determined all the limbs were untied, but the head was kept steadied in a head-holder so that head movements might not take place or be minimized. The present series of tests were intended to deal largely with the relation of the cerebrum to the leg and arm movements, and the head movements were disregarded except when the latter were associated with movements of the other segments. Since, however, the head was kept fairly rigid, most of the head movements were prevented and with the exception of a few have not been recorded. This procedure of steadying the head were also used for another reason, viz., to prevent possible injuries to the brain when the head moved at the time the stimulating electrodes were applied. Except by having the electrodes attached firmly to the skull so that they move with it, it is not always possible to avoid accidental injuries of this nature, but in the present series such avoidable injuries to the brain were prevented by keeping the head steadied.

A one-half inch trephine was used to cut through the skull to such a point that the button of bone could be readily removed. The trephine was not permitted to cut entirely through the inner table of the skull on account of the possibility that the trephine teeth might also cut through the dura mater and thus injure the brain. In this way also injury to the cerebral cortex was prevented as much as possible, and in no case, as far as could be determined by an inspection of the brain through a magnifying glass was any gross injury produced. After the skull openings had been made in this manner they were enlarged in different

directions by bone forceps in order to uncover a large portion of the frontal area, all of the so-called precentral region and a considerable part of the postcentral cortex. Bleeding from the diploë was checked by the application of bone wax. When the large openings on both sides of the skull had been made the bridge of bone which covered the longitudinal fissure was cut through after ligatures had been placed at both extremities of the bridge in order to prevent bleeding from the longitudinal sinus. In previous tests bleeding from this source was found to be very great and in one of the animals used in the present series even the precautions of ligating the longitudinal sinus which were taken did not prevent death from hemorrhage. The dura was next cut and this was partly reflected and partly cut away so as to leave the portion of the cortex which was to be stimulated bare.

The part of the brain which was not at the time being subjected to stimulation exploration was covered with thin rubber tissue which had been wet with warm normal salt solution and all was covered with a large sponge of cotton which had also been wet and warmed in the same solution. Sufficient time elapsed between the individual stimuli to permit the recording of results and this also rested the brain tissue. After a series of half a dozen or more stimulations the part of the brain which was being used was covered by the rubber tissue and the sponge, and the brain was permitted to rest for a longer period, five to ten minutes. In this way the brain was protected at times when the tests were not being made. In this way also drying could not take place, and little, if any, of the anæsthetic gases escaping into the room could act directly upon the cerebral cells. At the same time the use of the rubber tissue prevented too much moistening of the brain substance, for it should be recognized that there is a possibility that the use of too much of the normal salt solution may, by osmosis, sufficiently change the chemical character of the cortical cells to produce alterations in their irritability. The duration of the tests on one side of the brain was usually about three hours. In certain cases where the number of stimulable points was small this time was short-

ened and on one animal in which the number of points was large, this time was much increased. In addition to the careful administration of the anæsthetic, the precautions to avoid "fatigue" and those to prevent osmotic changes from the application of the moistening solutions tended to keep the cortical irritability at approximately constant level, and any experiment, if it had appeared necessary or advisable, might have been carried on for a greater length of time.

It was not found difficult to keep the animal sufficiently under the effect of the anæsthetic during the whole period of time, for care was taken that the quantity should be sufficient to prevent any voluntary movements which might mask or interfere with the movements which were produced by the electrical stimulations, but at the same time the anæsthetic was not pushed to such a degree as would be necessary in experiments in which complete relaxation of the involuntary muscles is desired. In no case was the anæsthetic deep enough to produce a relaxation of the sphincters, but by continuous careful application all of the voluntary movements were prevented, even at the times when cutting and trephining were performed.

The cortex was stimulated by the bipolar method, the induction coil being a standard Helmholtz apparatus. The platinum points were separated by approximately one-quarter of a millimeter and each of the points was approximately of the same size. The distance, therefore, between the centers of the points was approximately one-half of a millimeter. The electrode points were applied to a special portion of the cortex and after the stimulation and the resulting reaction (when any occurred) they were removed. The secondary coil of the inductorium was arranged at the beginning of a series of tests on an animal at such a point as to give a supra-minimal stimulation. It was kept at this point throughout the series of tests on that animal, with the exception that when with this strength of current an apparently non-stimulable area was found, the strength of the stimulus was increased to determine whether the failure of reaction was due to a normal non-stimulable character of the special area or to a decrease of irritability. It was found

that the increased stimulus seldom gave rise to movements, and when failures with the increased stimulus were encountered it was concluded that these areas were normally non-stimulable. It is likely that further increases in the strength of the stimuli might have resulted in reactions, but with greater strengths of stimuli the possibility of "spreading" is greater and the results would have been open to serious objection on this score.

The stimulations were usually first begun at the upper portion of the precentral area where the motor cortex dip downwards into the longitudinal fissure. Eight or ten stimuli were given in a regular order as close as possible to the central fissure, and extending serially towards the fissure of Sylvius, the stimulated points being approximately one millimeter apart. Another series was begun at the extreme upper limit of the precentral area and the stimuli were carried downwards in a line which was approximately one millimeter in front of the line along which the previous series of stimuli had been given. Third, fourth, etc., series were made in the same manner, each extending one millimeter anteriorly to the previous one. In this way the experiment was carried on until in passing forwards a line or series of stimuli had been given which produced no observable reactions. In certain animals, on account of the presence of blood vessels and extra fissures, lines in which no stimuli were given were present. In most cases, however, the blood vessels which were encountered were not much greater than one millimeter in diameter and thus the general experimental relationships were not markedly disturbed. After such an area, about ten millimeters in length and in width to correspond to the stimulable zone, had been carefully examined, similar series were made in the area immediately below (towards the fissure of Sylvius). In this manner the whole of the superficial precentral cortex extending from the longitudinal fissure downwards as far as the head area was carefully mapped out.

After every second stimulation a small portion of a mixture which was composed of vaseline and analine-black was applied to the point which had been previously stimulated. This mixture was viscid, and sufficient could be taken upon the point of

a sharp probe which, when lightly touched to the brain, left a speck of this "paint" upon the brain surface. In some cases the individual points did not stand out by this method as clearly as was desired, but in many of the experiments the points of application of the analine-black mixture could be correctly determined and the relative locations of the individual points of stimulation were therefore accurately given on the cortex. The application of the wet rubber tissue and sponge after a series of tests tended to obliterate the marks which were made, but the pia mater (and the brain?) was sufficiently stained in many cases so that the individual points were to be seen when the brain was examined with a magnifier. The stained points were later compared with the photographs and with the diagrams which were used.

At the time of the performance of the experiment a rough sketch (with a magnification of about ten diameters) of the general appearance of the precentral and postcentral regions of the hemispheres was made. On this sketch the longitudinal fissures, the central fissures, subsidiary fissures, and the blood vessels were noted. Following each test the location of the stimulated point was marked on the sketch so that this could be compared with the location of the stain which had been applied to the brain. The serial numbers of the tests were noted on the sketch in approximately correct relations. These sketches were subsequently used for the identification of the stimulated points. After the removal of the brain and its hardening in formalin (10 per cent) the area which was found to be stimulable was again sketched by placing over the cortex a piece of transparent paper which was pressed down tightly and which was marked to show all of the points of interest (fissures, blood vessels, extent of the stained zone, etc.) in that particular area. These diagrams were then placed in the Leitz projection apparatus and drawings were made of the results with a magnification of ten diameters. On the drawings which accompany the present work corrections have been made in the diagrams by comparisons with actual brain pictures (photographs), so that the diagrams which are here represented are combinations of the sketches taken at

the time of the performance of the experiments with the actual pictures of the brains. At the time the brain was photographed a two millimeter scale was placed along the central fissure and photographed with the brain. The photographs were later magnified uniformly at 10 diameters, each millimeter on the photographed scale corresponding to 10 on the diagram, and drawings made of all the important landmarks.[2]

On these drawings the points of stimulation were noted and the numbers corresponding to the serial tests were recorded. Since the diagrams were drawn to scale, the results which are recorded in them may be considered to represent fairly accurately the extents of the stimulable motor areas in the individual hemispheres of the five monkeys which were used. It will be noted that these areas differ considerably in absolute sizes, monkey 2 having a more extensive responsive area than any of the other animals, monkey 4 having the least extensive stimulable motor area.

At the time the experiments were performed there were usually four observers. The chief duty of one was the manipulation of the electrodes. This observer also directed the experiment, noting on the rough sketch the points which had been stimulated and

[2] Since there is a considerable curvature of the brain from the longitudinal fissure towards the temporal areas (of special interest in this connection being the curvature in the region of the central fissure) the photographs showed considerable spatial distortions of the sides of the brain. In the projection of the photographs only the two millimeter divisions on the relatively flat superior surface of the brain could be made to correspond with the twenty millimeter divisions of the projection screen. The landmarks (fissures, blood vessels, etc.) and the scale divisions were recorded as they were magnified. These drawings were then dealt with as if the curved surface was simple, *i.e.,* like that of a cylinder, and the proper geometrical projections were made to bring about the uniform distribution of the area. It is realized that for the most accurate representation we should deal not only with the superior-inferior curvature but with the fronto-posterior curvature as well. The latter curvature in the region of the central fissure is however slight as compared with the superior-inferior curvature and has been disregarded. The error of recording due to this method is, I am advised, probably not as large as 5 per cent. Since also these drawings were later compared with the brains, with the enlarged diagrams on transparent paper, and with the original sketches, the error is doubtless much less than this amount. It is presumed, however, that the error is about equal for all brains and the results are, therefore, comparable.

applying to the cortex the analine-black mixture. A second observer took charge of the anæsthetic, his attention being directed principally to the matter of keeping the animal under good anæsthetic control, but he assisted at times in the observation of the activities of the animal which accompanied the stimulations. A third observer recorded the results of the individual stimuli on sheets of paper, noting at the same time the serial numbers and the times of the stimulations. This observer also coöperated with the fourth one in noting the character of the movements. The fourth observer had as his sole duty the observation of the movements which resulted from the stimuli and the description of the movement so that they might be recorded. As has already been said, the anæsthetist also occasionally helped to observe the movements. Only when the two or three special observers of the reactions (movements) were satisfied regarding the characters of the reactions were they recorded. If there was a doubt of a more or less serious nature regarding the combination of movements which was produced the particular point was subjected to a second stimulation at a later time.

Following the determination of all the available points in the leg and arm areas the animal was killed by an overdose of chloroform. The brains were hardened in formalin and preserved for future study. The extent of the stimulable areas was determined in the manner described above after the brain had been thoroughly hardened. The location of the points for the individual segments or parts of segments was also made in the manner similar to that described above, and are here reproduced in the diagrams.

The serial numbers of the original individual tests have not been included in the present accounts, for to bring about an areal correspondence of the allied areas in all animals the serial numbers in the individual experiments were not available. This was due to the fact that variations in the conduct of the experiments, *i.e.*, the varying location of the different fissures and different blood vessels, etc., were present to alter the constant serial character of the experiments in the different hemispheres.[3] Furthermore, in

[3] That is, test 10, or test 36, or test 72, did not always bear the same relation to the well known anatomical landmarks in all hemispheres.

the illustrations which are given later the areas have been, for the purpose of comparison, divided into special zones, although it should be understood that these zones by the methods used, are only approximately determinable for any one hemisphere.[4] At the same time, since the individual areas differ widely in extent, it should be noted that spatial comparisons of two or more hemispheres can be only approximate.

In the present work as has been noted above, attention was directed to those areas which are concerned with the movements of the leg (including the thigh, lower leg, foot and toes) and with the arm (including the shoulder, forearm, hand and fingers). The associated movements of the head which were occasionally met with in the stimulation of the arm area will not be detailed in the present paper. The present paper, therefore, deals primarily with the areas concerned with the anterior and posterior limbs and occasionally with the associated movements of the tail. The results of the experiments are given in four divisions as follows: (1) the total extents of the stimulable areas for the arm and leg; (2) a comparison of the distribution for the leg and for the arm; (3) a comparison of the distributions of the areas for the smaller segments (fingers, hand, lower arm, upper arm, toes, foot, lower leg and thigh); and (4) the anomalous distribution of the stimulable areas, namely (*a*) those areas which gave leg movements when the surrounding areas gave arm movements, (*b*) those areas which gave arm movements when the surrounding areas gave leg movements, and (*c*) the nonstimulable (or relatively non-stimulable) areas which were surrounded by readily stimulable areas.

Several possible objections may be urged against considering the diagrams to include all of the motor responsive areas for the arm

[4] In other words, in the diagrams each point of experimental stimulation is represented by an area. Since the stimulated points were one millimeter apart, the square millimeter surrounding a point was considered to correspond with the point. A micrometric method of moving the stimulating electrodes or the use of one pole, by the unipolar and monopolar methods, would have permitted the stimulation of more points, and the diagrammatic representations would have been nearer the actual conditions. Since, however, we deal with comparative results with the same method on all animals the slight variations due to method can be largely disregarded.

and leg. One possible objection is that the stimuli may not have been sufficiently strong to bring about responses in the outlying portions of the areas, and that in any one of the monkeys the total area which was found stimulable may be only the combination of more readily stimulated points. Such an objection would be valid were it not that in those cases in which the extent of the area seemed to be slight, additional slightly stronger stimuli were given in order that there should be a reasonable certainty regarding the outer limits. When these increased stimuli failed to produce a response it was deemed that the limits of the normally excitable area had been reached. The use of much stronger stimuli may be objected to in this connection, since the stronger stimuli tend to spread to a great degree and, therefore, to have a more widespread physiological effect than the weaker stimuli. Since the precautions were taken however, as a check and negative results were obtained, the negative results may be considered to be confirmations of the limitation of what we may call the "immediately" excitable zone.

Another objection which may be urged against considering these results of absolute (rather than relative) value is that no account has been taken of the stimulable portions of the cortex which are included within the central and within the subsidiary fissures. This objection is in most respects weighty for it is realized that there may be a possible inverse relation between the amount of the stimulable cortex on the convexity or surface of the brain and that to be found lying within the fissures. It may be admitted at the outset that in the present work no measurements (stimulation or otherwise) have been made of the quantity or extent of the motor cortex which dips down into the central fissures. It may also be admitted that some of the variations which have been discovered by the present methods may be variations of an anatomical nature as described above (inverse relation of surface and fissure extents). It is not true, however, that all the variations can be explained in this manner. Some variations that will be noted later, especially those of the distribution of the areas for the individual segments cannot be explained in this manner. On account of the possible objection to certain of

the results it may be mentioned that the correlation of the extent of the motor cortex anterior to and that within the fissure of Rolando is a problem which I hope to be able to deal with in a subsequent publication.

A third objection is that the motor areas dipping downward into the longitudinal sulcus have not been considered. In most of the hemispheres this objection does not hold since the areas within the longitudinal sulcus were investigated and the results recorded. In the case of the left hemisphere of monkey 3, however, not even all the convexity surface was investigated, as will be noted below.

EXPERIMENTAL RESULTS

Before proceeding to the accounts of the results of the experiments it appears desirable to present a series of figures which describe numerically the brains of the animals on which the experiments were performed. These figures are given for the reason that the areal variations of the stimulable zones might have correlations with the brain sizes or brain weights. Because of this there are given various linear measurements and diameters since the selection and use of one measure for possible correlation might be considered to be too arbitrary. The measurements were made approximately one year subsequent to the performance of the tests, after the brains had been continuously in formalin (10 per cent). All measures were taken in the nearest half millimeter or nearest half gram.

The diameter measurements which are recorded were made with slide calipers. The total length was taken as the longest diameter between the frontal and occipital poles. The total width is the greatest side to side diameter. This is sometimes found caudad to the position of a plane from the upper portion of the central fissure perpendicular to the longitudinal sulcus. Since the measurements just noted can give only a general view of the brain as a whole it was also thought best to take data referring to the frontal (anterior to the central fissure) portions of the brain. The frontal width was taken on each side from the longitudinal sulcus to the side of the bzrain, on a plane passing through the central fissure approximately one-half of the distance from the longitudinal sulcus to the end of the central fissure near the fissure of Sylvius. The frontal length is also given for the two sides separately. It is the distance between the anterior tip of the brain and a plane passing through the brain and beginning at the origin of the central fissure near the longitudinal sulcus and perpendicular to the latter. The length of the central fissure could not be measured as accurately as the

lengths already mentioned. A narrow pliable but non-stretchable tape was laid along the fissure beginning at either its superior or inferior end and passing over its various curves as well as possible. The weights of the brain were determined to the nearest half gram, the weights being of the cerebrum alone. The medulla, cerebellum and spinal cords had not been preserved. Three measurements of each kind were made; the results were averaged and in the table the averages are noted to the nearest half millimeter or half gram.

The brain of monkey 4 was slightly flattened on the left side in its superior-inferior diameter. This was probably due to the usual cause, lack of sufficient protection from the bottom of the containing vessel. At the same time this flattening may have been accompanied by an elongation or a broadening of that side. Since, however, the two sides gave approximately (within 0.5 mm.) the same fronto-occipital measurements it does not appear likely that there has been much variation in this particular. On the other hand, the variations in width are found to differ for the two hemispheres of other animals and it is impossible to say with surety that the superior-inferior flattening was the cause of greater width of the left hemisphere of this animal. When the brain of monkey 5 was removed from the skull both occipital lobes were accidentally cut and in the process of hardening some

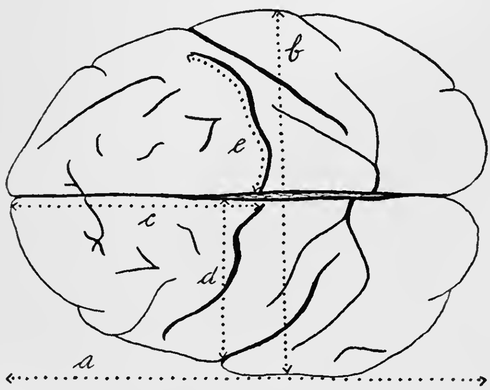

FIGURE 1. Representing the methods of making the linear measurements which are given in the text and in Table I: *a*, total length; *b*, total width; *c*, frontal length; *d*, frontal width; *e*, length of central fissure.

separation of these parts from the remainder of the brain occurred. When the brains were measured these parts were approximated to the remainder of the brain and the measures made. If there is an inaccuracy in the measurements of this brain because of this such inaccuracy relates probably solely to the total length. The measurements which have just been described are given in Table I and the methods of taking the linear measures are illustrated in Figure 1.

TABLE I. Measurements of Monkey Brains. All linear measurements are given in millimeters; those of mass in grams. The brains of monkeys 4 and 5 were somewhat distorted when measured, and the linear measurements may differ slightly from those given here (see text, page 93, for explanation).

Monkeys	Total Lengths	Total Widths	Frontal Widths		Frontal Lengths		Lengths of Central Fissure		Weights
			R	L	R	L	R	L	
1	70.0	52.0	21.5	24.0	34.0	36.0	32.0	33.0	69.0
2	67.5	48.5	23.5	24.0	32.5	37.0	33.0	33.0	65.0
3	74.0	54.5	24.5	26.0	41.0	39.5	36.0	37.0	81.5
4	67.5	50.0	21.0	23.0	35.0	36.5	33.0	28.0	59.5
5	66.0	51.0	24.0	22.0	36.5	35.0	29.0	30.5	60.5

The measurements show that monkey 3 had the longest, the widest, and the heaviest brain and, whether measured by the *product of frontal width x frontal length,* or by *frontal length x length of the central fissure,* which products may reasonably be supposed to give an indication of the extents of the frontal areas, also the largest frontal area. This, as will be pointed out in a subsequent section of this report, is of special interest in connection with the extent of the stimulable areas. In respect to the similar measures of the brain of monkey 1 it will be noted that the right hemisphere of this animal was found to be among the smallest, although the brain weight and total length are greater than those of monkeys 2, 4 and 5. At the same time it will be noted that the brain weight of monkey 2 is the median, that the total width is the least, and that the products of *frontal width x frontal length* and *frontal length x length of central fissure* are not much greater than those of the brain of monkey 1.

I. EXTENTS OF CEREBRAL MOTOR AREAS FOR THE ARM AND LEG SEGMENTS

Monkey 4 died shortly after the stimulation experiment had been begun on the left hemisphere. Death appeared to be due to an excessive hemorrhage from the longitudinal sinus which had not been suitably ligated. The results of the experiments on this animal can, therefore, be given for only one hemisphere and in this case the comparison of the two hemispheres is impossible. A general view of the results on all animals is given in Figure 2. As has already been mentioned, the points of stimulation have been dealt with as if they were areas corresponding with the spaces surrounding the stimulation points. The results of the experiments on each hemisphere are shown separately, the digits referring to the monkeys, the upper diagrams showing the results of the experiments on the right hemispheres, and the lower diagrams showing those on the left hemispheres of these five animals. The areas for the leg segment movements are represented by horizontal lines and those for the arm segment movements by vertical lines. The heavy horizontal lines represent the respective longitudinal sulci, other heavy lines represent the principal fissures (that of Rolando, or the central fissure, being very plain) and the three parallel lines indicate the locations of the principal blood vessels.

It will be first noted that the shapes of the areas differ considerably. In some cases the areas appear to run practically parallel to the central fissures (1R, 1L, 3R, 3L).[5] In other cases the form of the areas is irregular, broader at the top, or near the longitudinal sulcus, *i.e.,* near the upper portion of the Rolandic fissure, and narrower below. It is also to be noted that in some cases, and in all hemispheres in certain locations, the areas are solid, while in others there are zones in which no leg or arm reactions were obtained. In some of these cases the points were

[5] These figures and subsequent ones mean monkey 1 right hemisphere, monkey 1 left hemisphere, etc.

apparently "silent" since no movement of the arm, trunk, tail or head segments followed stimulation, but in a few cases on the other hand the stimulation of these areas gave movements of the head or of a segment other than those which are dealt with here (*i.e.,* arm and leg). These anomalous results will be discussed in a later section of this article (see p. 134 ff.).

A third difference which is obvious is that the overlapping of arm and leg areas is irregular. In the brain of monkey 1 none of this overlapping was discovered, very little was found in the brains of monkeys 3 and 4 and more was found in the brain of monkey 5, and a considerable degree of overlapping was discovered in the brain of monkey 2. These overlappings will also be dealt with in a subsequent section (see p. 128 ff.).

A further difference, which may however be only casual, is that the dividing line between the leg and arm areas is at times well marked by fissures or by blood vessels and in the brains of other animals these anatomical landmarks do not appear to have physiological differentiating characters. Those hemispheres in which fissures and blood vessels mark off the two areas under consideration are 1R, 1L, 2L, 3L, and 5L. I do not think that the greater frequency of this in the left hemispheres, or in fact any of the differences in this particular can, with our present knowledge, be considered to be of physiological significance.

A closer examination of the figures also reveals well marked differences in the totals of the stimulable areas. It is obvious from inspection that the stimulable areas of 2L is greater than that of all other hemispheres which have been examined. It is also apparent that in this respect there are great variations, hemisphere 4R shows the smallest area and the remaining seven hemispheres are intermediate between 4R and 2L. As has already been indicated (p. 91) there was an experimental error in connection with hemisphere 3L inasmuch as there was a possible line bordering upon the longitudinal sulcus which was not subjected to stimulation. In this one case had the stimuli been given to points in this area it is possible that the leg area would have been found to extend correspondingly in the wedge shape upwards to the longitudinal sulcus.

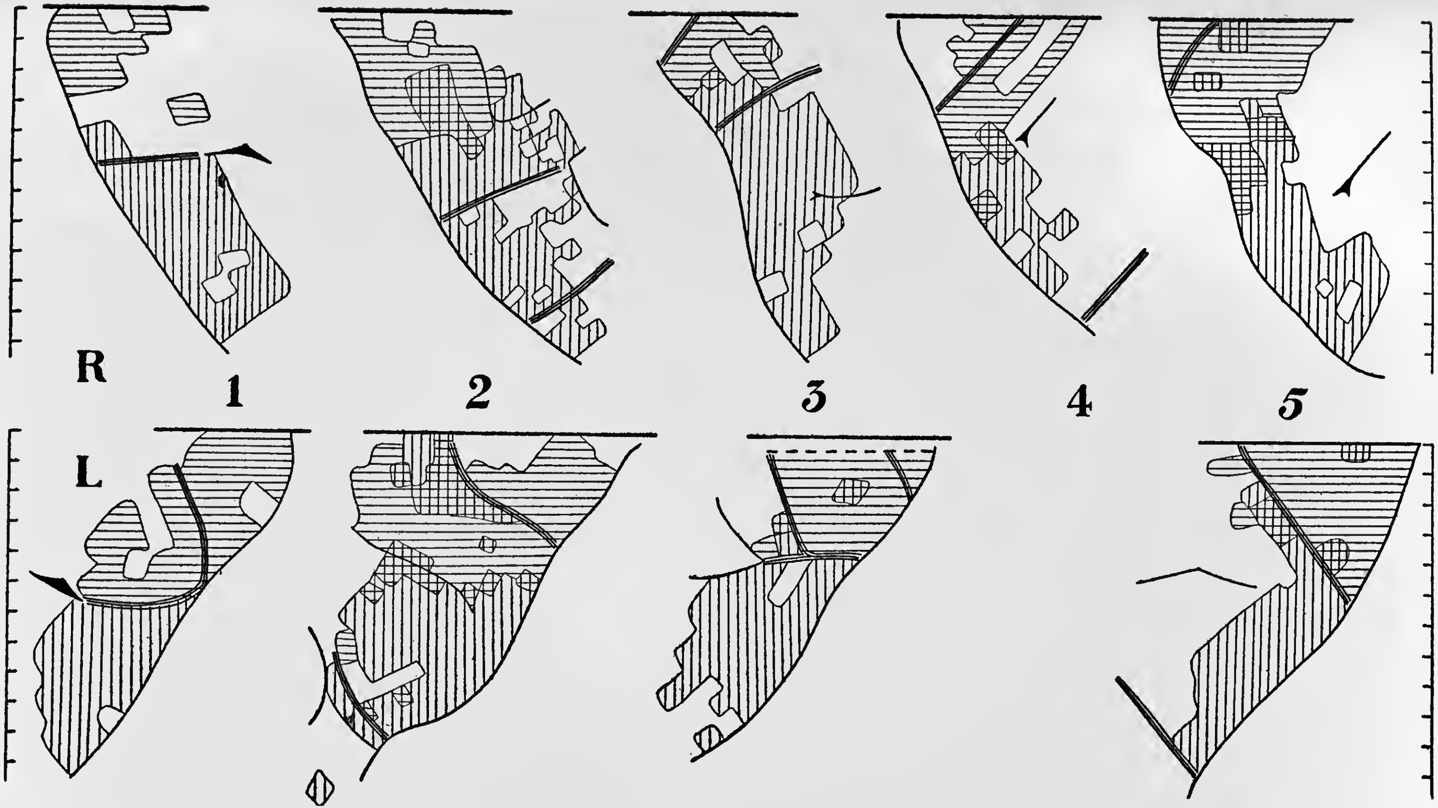

Figure 2. The total extents of the cerebral stimulable areas for the leg and arm segments. Horizontal lines = leg areas; vertical lines = arm areas; combined (cross-hatched) lines = arm and leg areas (*i.e.*, combined movements). Blank spaces are inexcitable, or have relation to movements of parts other than those discussed here. Fissures are shown by heavy lines, the principal blood vessels by three parallel lines. The upper series of diagrams represent the right hemispheres, the lower series, the left hemispheres. Scale marks indicate 2 mm. divisions.

More careful measurements of these areas reveal the differences which are observable on inspection. The figures representing these measurements are given in Table II. The measurements were made from the magnified (10 diameters) charts

TABLE II. Measurements of Areas of Stimulation of Monkey Brains. Figures marked with an asterisk are probably too low. For explanation of this see the text, page 91.

Monkeys	Hemispheres	Areas in square millimeters					Per cent Leg / Arm
		Leg	Arm	Totals	Overlappings	Net	
1	R	33	82	115	0	115	40
	L	86	71	157	0	157	121
2	R	61	106	167	15	152	58
	L	124	125	249	34	215	99
3	R	25	103	128	4	124	24
	L	57*	80	137*	5	132*	71*
4	R	51	34	85	7	78	150
5	R	79	83	162	23	139	96
	L	78	77	155	11	144	101

which have been described, by the aid of a transparent die divided to show actual square millimeters (in the magnified form square centimeters, of course) which was placed over the areas. Each full square covering the stimulable zone was counted as one and each part square as one-half, the latter on the supposition that the areas larger than one-half would counterbalance those smaller than one-half. The results of this comparatively rough method were compared in one case with the similar finer method of using a die with spaces representing half-millimeter squares, and since the variations did not greatly exceed one per cent the original measurements were considered to be sufficiently accurate. The method of measurement is also obviously exact enough in view of the methods which were employed for the limitation of the areas involved, and especially in view of the magnified representations of the areas which were measured. It should be remarked, however, that a turning of the die through an angle of 30 degrees varied the measures by as much as 6 per cent but even with this variation the figures appear to be sufficiently exact as they stand.

In connection with the table mention may be made again of the fact that in hemisphere 3L an area lying next to the longitudinal sulcus was not stimulated. The figures in columns 3, 5, 7 and 8 referring to this hemisphere are, possibly, too low.

At the present moment attention should be directed solely to column 7 of this table in which are given the net totals of the areas which were found to be stimulable. These figures show that the stimulable area of 4R is the smallest, that of 2L the greatest. In terms of percentage, using the lowest figure as 100, we find that the other hemispheres take the following order and show the following percents: 1R (149); 3R (159); 3L (169); 5R (178); 2R (195); 1L (201); 2L (276). It will thus be seen that the greatest area (2L) is almost three times as large as that of 4R, and that the other seven hemispheres vary from 50 per cent to 100 per cent greater than the smallest.

These data show that not only are there marked variations in different animals, but also that the variations of the two hemispheres of the same animal are sometimes great with respect to the stimulable (motor) areas. These differences of the two hemispheres of the same animal are worthy of some notice. In all four monkeys of which both hemispheres were investigated and measured it will be noted that the stimulable areas on the left surpass those on the right. In the case of monkey 5 this left-sided preponderance is not great, only 3.6 per cent and therefore within the error of measurement, and similarly in the case of monkey 3, only 6.5 per cent, close to the error of measurement. In the latter case, however, there should be recalled the suggestion (see p. 96) of the possibility that the leg area should be considered to be larger than it is sketched. With respect to monkeys 1 and 2 the preponderance of the left side is great, 36 and 41 per cent respectively. In the next section a further analysis of these figures will be made to determine the relative areas for the arm and leg movements separately.

To what factors these differences correspond is at present unknown. Certain of the general objections to considering them typical of the motor cortex have already been discussed

(p. 89 ff.) and the general relation of the differences to our conception of cerebral activities will be considered in the section devoted to the theoretical discussion (p. 140 ff.). At this point, however, it may be well to show the general lack of correspondence or correlation with the measurements of the brain which have been recorded in Table I (p. 94). Monkey 3, with the greatest brain weight, greatest length of hemisphere, and greatest width of the cerebrum did not have the most extensive motor area as determined by the methods which were used in the present work, while monkey 2, with one of the smallest brains in the series showed the most extensive excitable areas. If the measures which have been used (*frontal length x frontal width,* and *frontal length x length of central fissure*) are at all typical of the amount of the cortex of the frontal areas, it is plain that there is no direct relation between the extent of the motor or stimulable cortex and the total amount of the cortex anterior to the central fissure. Such a conclusion becomes more evident if we deal with the data regarding the other hemispheres. The only apparent fact which indicates a possible relation between brain size (or amount of frontal cortex) and the extents of the motor area is that there is a closer correspondence between the relative sizes of the motor areas and the total areas of the frontal lobes in the two hemispheres of the same animal. Thus, it might be concluded that the preponderance of the motor area of the left hemisphere is an indication of and bears a possible correlation with the (in general) larger hemisphere measurements on that side. Monkey 1 whose brain showed greater width, greater frontal length, and greater length of the central fissure on the left showed also a considerable superiority in the extent of the motor area on that side. The brain of monkey 2, in which a similar superiority in size was apparent, except for fissure length, also showed a larger area on the left side. The brain of monkey 3, in which there was a greater width and a greater fissure length on the left while the left frontal length was smaller than that on the right showed little difference in the relative sizes of the two motor areas. In a similar manner the brain of monkey 5 showed variations

in measurements, some of the right hemisphere being greater than those of the left and others of the left being greater than the corresponding measures of the right hemisphere. The cerebral measures which may be concluded to be approximately balancing for the two sides correspond therefore with the almost equal distribution of the motor areas. A disturbing element to such a conclusion is due to the unfortunate failure to complete the series of experiments on the left hemisphere of monkey 3. While there is an equal reason for believing that if the stimuli had been given in this area there would and there would not have been any great change in the sum totals of the areas, at least the case must tentatively be thrown out of consideration. Another fact which is opposed to the conclusion of such a definite relation is found in the lack of correspondence between the relations of the hemisphere measurements and the relations of the extents of the excitable zones. Those measurements which have been taken to represent the areas of the frontal lobes (*frontal length x length of the central fissure,* and *frontal length x frontal width*) do not have the same or nearly the same proportions that the total motor areas of the two hemispheres of the same animal bear. Thus our relative measures for the brains R/L are as follows: *frontal length x frontal width,* 1 = 0.85, 2 = 0.86; 3 = 1.01; 5 = 0.99. To compare with these figures we have the similarly calculated relations of the two motor areas of the same brains as follows: 1 = 0.73; 2 = 0.71; 3 = 0.94; 5 = 0.97. The absolute figures do not show a close correspondence but it must be admitted that the measures are grossly inaccurate as representing the area of the anterior parts of the cortex of the cerebrum. If we consider the relative figures there appears to be a closer correlation inasmuch as the relatively smaller motor areas on the right (monkeys 1 and 2) may be compared (not directly, however) with the smaller cortical zones on that side. At the same time the nearly equal motor areas (monkeys 3 and 5) are to be compared with the nearly equal cortical zones (or with the preponderating right hemisphere of monkey 5 as indicated by *frontal length x frontal*

width). We can conclude with certainty that if a relation in this respect exists it is neither simple nor direct.

Summary: The motor areas for the leg and arm segments differ in size in the brains of different animals, and in the two hemispheres of the same animal. These differences are not accounted for by the size variations of the hemisphere of the the different animals although there is some indication of a possibility of correlation of the sizes of the frontal lobes and the extents of the motor areas of the two hemispheres of the same animal.

II. RELATIVE DISTRIBUTIONS OF AREAS FOR LEG AND ARM MOVEMENTS

Figure 2 and Table II also contain data regarding the absolute and relative extents of the respective areas for the movements of the posterior and the anterior limbs. Examination of the parts of the figure and of columns 3, 4, 7, and 8 of the table reveal extensive differences. These differences are (1) varying amounts of cerebral areas in different animals for the leg and for the arm movements, (2) varying amounts of cerebral areas in the two hemispheres of the same animal for the leg and for the arm movements, (3) variations in the overlapping or mixing of the leg and arm areas, which matter will be reserved for discussion in a subsequent section, and (4) variations in the spatial proportions of these two areas in the same hemisphere.

The individual variations in extents of these areas should first be noted. The smallest leg area was found in 3R, the largest in 2L. The smallest arm area was found in 4R, the largest in 2L. The largest leg and arm areas were found in the hemisphere with the largest total area, which as noted above was by no means the largest brain. The smallest leg area was not found in the hemisphere with the smallest total stimulable zone, but the smallest arm area was found in the hemisphere with the smallest net total stimulable area. The intermediate sized total areas more closely correspond with the order of magnitude of the leg areas than with those of the arm areas. Thus we find the order of magnitude of the net totals of the stimulable zones (combined arm and leg areas) are 4R, 1R, 3R, 3L, 5R, 5L, 2R, 1L, and 2L; the order for the leg areas is 3R, 1R, 4R, 3L, 2R, 5L, 5R, 1L, and 2L; and the order for the arm areas is 4R, 1L, 5L, 3L, 1R, 5R, 3R, 2R, and 2L. The serial orders indicate a rough correlation between the individual arm and leg and the net total areas, with a greater correspondence of net total with leg areas. When, however, the percentage relations of the individual areas are considered it is to be noted that the only close correspondence is in the hemispheres in which the leg and arm areas are nearly equal in size. Thus we find in

general a fairly close correspondence in the cases of 2L, 5R and 5L, but in these cases with the leg and the arm areas each about one-half of the total, a direct and proportional correspondence is obviously the only possible relation that can exist.

When we examine the table we find that in only monkey 5 are the totals of the areas for the leg and for the arm closely similar for the two hemispheres. The almost exact correspondence of areal distribution for the leg movements is noteworthy and the differences in the sizes of arm areas in this animal are not great, perhaps not much greater than the errors of recording and of calculation. The only other close correspondence is for the arm areas of monkey 1, but in this case the variation is approximately fifteen per cent. In the other five cases (hemispheres) the differences are greater, the variations ranging from 18 to over 100 per cent. In the left hemispheres of monkeys 1, 2 and 3, the leg areas are larger than those of the right. In the left hemisphere of monkey 2 the arm area is the larger, while the arm area is larger in the right hemisphere of monkey 3. It will be noticed, therefore, that the left motor areas for the leg are in general considerably larger than those on the right, while a reverse condition holds for the arms areas of the two hemispheres with the exception of monkey 2 and also with the exception that the differences are not as great.

If other data were not at hand such variations might reasonably be thought to bear a possible relation to the sizes of the hemispheres, but an examination of the figures in Table I and comparisons with those of Table II show that no such relation exists.

Coupled with the individual and the hemisphere variations of these areas we may also consider the relations to each other of the leg and arm areas of the same hemisphere. In this comparison we note even greater deviations than have already been discussed. The quotients of leg area divided by arm area for the individual hemispheres are shown in column 8 of Table II. The smallest is that of 3R, the largest is that of 4R. In three hemispheres (2L, 5R, and 5L) the quotients show the two areas to be about equal, in four hemispheres the quotients show considerable spatial superiority of the arm area (1R, 2R,

3R, and 3L), and in two hemispheres a corresponding superiority of the leg area (1L and 4R). Although the importance of the observation is not apparent it is interesting to find that in the four cases in which figures for both hemispheres are available the relative superiority of the arm area is more noticeable on the right. It will be noted also that in three of these cases (monkeys 1, 2, and 3) this relative superiority is large and, in the other case, although small, it is indicated by a difference of at least 5 per cent.

An explanation of these differences cannot be given at the present time. I greatly regret that extended observations of the behavior of the animals were not made previous to the experiments, for, merely to speculate, the suggestion occurs that these cortical variations may have some relation to the normal activities of the individual animals. A few observations regarding the use of the right and left hands of some of the animals were made but the data are so few that they give no clue to a possible relation between the extensive or limited arm areas in one hemisphere and the use of the right or left hand or arm. It is for our present purposes unfortunate that even these inadequate tests were not continued a sufficient length of time with one animal to make certain any preference in the employment of the hands. The suggestion of a possible correlation of the areal differences and the differences in behavior is directly in line with previous conceptions of cerebral function, especially those regarding the relations of the associational areas to occupations and habits of thought. An extended series of observations of habits, general activity, etc., of many animals is needed along with corresponding observations of the stimulable areas before the truth of such a supposition can be determined.

Summary: The areas for the arm and for the leg differ to a considerable extent in different animals, and to an equal degree in the two hemispheres of the same animal. The leg areas are sometimes larger than, more frequently smaller than, and at times approximately equal to the corresponding arm areas. In the two hemispheres of the same animal the quotients of leg area divided by arm area are not even approximately equal, the proportions varying by as much as one to three.

III DISTRIBUTIONS OF THE AREAS FOR THE INDIVIDUAL SEGMENTS

Up to this point we have dealt with the areas for the arm and leg as if these were the main anatomical (and physiological) elements which were to be considered. It is obvious, however, that the individual segments of these larger anatomical units are worthy of more and closer study. We shall also find that the variations which have already been shown to exist are not only paralleled, but in a number of cases they are exceeded in amount, by the variations in relative sizes of the areas for the smaller segments. At the present time the analysis and comparison of the types of the movements have not been attempted, nor will the separate finger or toe movements be dealt with individually. For the present study I have made eight groups of movements as follows: *thigh,* which includes all mass movements of the leg on the trunk, such movements being of the upper part of the leg; *leg,* those movements at the knee; *foot,* those movements at the ankle; *toes,* movements of these elements taken collectively and not at the present time differentiating the movements of individual toes; *shoulder,* those movements of the upper arm in relation to the remainder of the body; *forearm,* movements of the elbow; *hand,* movements of this organ at the wrist; and *fingers,* movements of these parts, also collectively without differentiating the movements of the individual fingers or the thumb. At the same time I have for the present disregarded the characters of the movements, (1) whether they be flexions, or extensions, or rotations, or (2) dealing with the movements as they appear in their complexity as behavior phenomena, whether they be of a thrusting, or of a grasping, or of a propulsive, or a reaching, or of any other complex nature. In this section, therefore, I deal with the movements of anatomical segments and not with the movement characters.

Thigh.—The distributions of the areas the stimulation of which resulted in movements of the thigh are shown in the diagrams of Figure 3. The relative areal variations are here

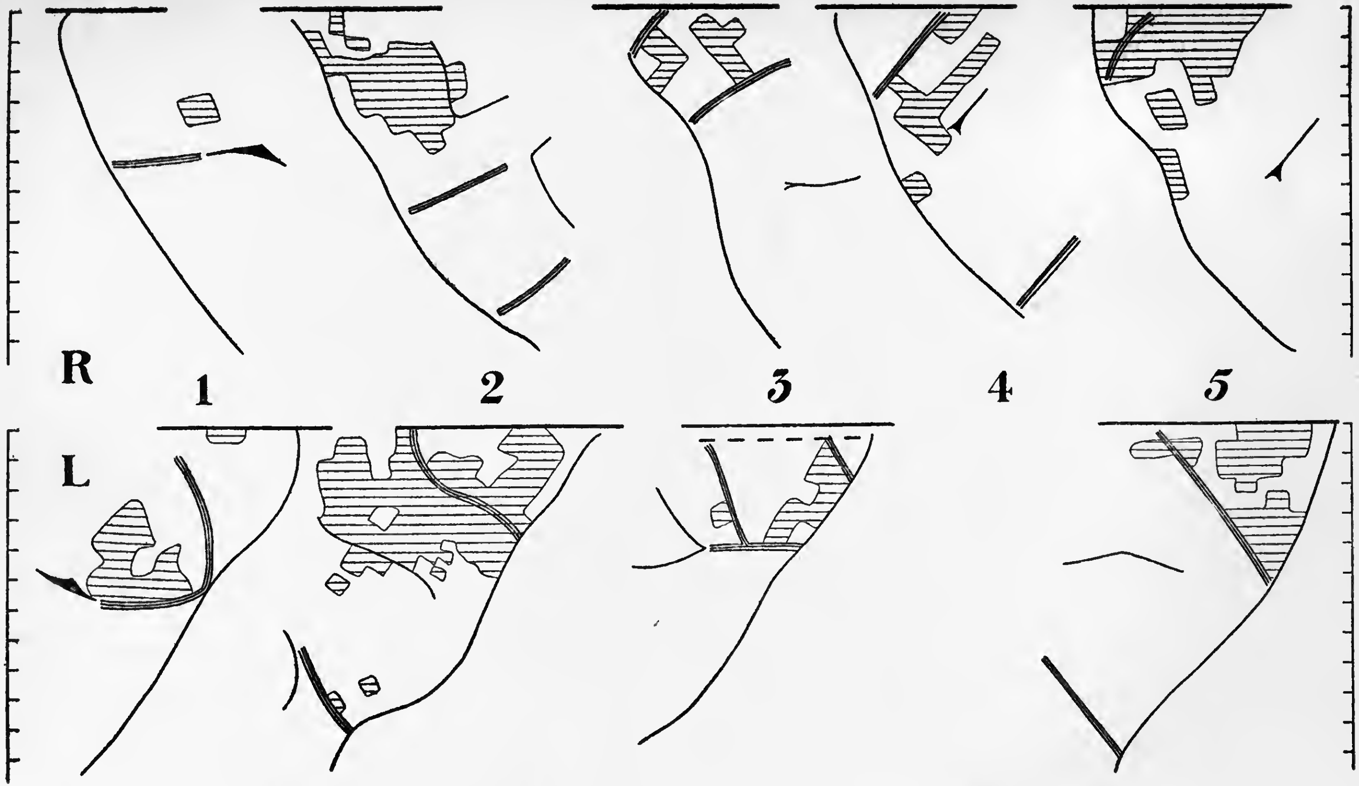

FIGURE 3. The extents of the cerebral stimulable areas for the thigh. Designations the same as in Figure 2.

observed to be much greater than those for the combined leg segments as shown in Figure 2, or than those for the arm segment as shown in the same figure. In two hemispheres, 1R and 3R, these areas do not touch the longitudinal sulcus, while in all other cases (omitting 3L which as has already been mentioned was not sufficiently investigated in this respect) the thigh areas border upon this great fissure. It is also to be noted that with the exception of the two hemispheres of monkey 1, and it may be said that the left hemisphere of this animal is a rather doubtful case in this particular, all of the thigh areas border upon the central fissure. In some of the cases the locations are suggestive of outcroppings from the central fissure, and of extensions of similarly functioning cortical zones lying within that fissure. In the same way we may consider the areas bordering upon the longitudinal sulcus although this appears a less probable explanation, except in the case of monkey 5. In all other animals there is a constriction of the area towards the longitudinal sulcus, the greater extents being on the convexity away from that zone.

The extensive variations of the area are shown in the accompanying Table III which gives numerical expression to the diagrams. Reference to this Table will be sufficient without

TABLE III. Measurements of the extents of the thigh areas. The figure marked with an asterisk is probably too low (see page 91) and the corresponding percentage R/L too high.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	4.5	30.0	47.5	107.0	17.5	*16.0	25.0	53.0	46.0
Percentages R/L	15		44		109		—	115	
Percentage relations of averages, Monkey 2 = 100.	22		100		22		32	65	

any textural discussion, since the data are self-explanatory. The attention of the reader is particularly directed to the two final lines in which are noted (1) the proportions of the areas in the two hemispheres of the same animals, and also (2) the percentage relations of the average extents of these areas in the five animals, using the largest average as unity.

In addition to the variations in the absolute and relative sizes of these areas the distribution of the stimulable zones is worthy of remark. With the exception of 1R, in which there appears only a small superficial area, all brains show a wide-spread distribution. In no case (except 1R) is the area solid, but the points are frequently separated by the cerebral zones for other movements or by the so-called silent or non-stimulable areas. In some cases this separation, which will also be found illustrated in some of the later diagrams, is noteworthy since the separated areas are within the zones governing the movements of the arm segments and also because they are at such relatively great distances from the main masses of the cortex which may appropriately be called the primary areas. In 1L and in 2L these separations are especially great.

Leg.—Similar variations in the extents and in the distribution of the areas governing the movements of the lower part of the leg are to be noted by inspection of the diagrams of Figure 4 and the data in Table IV. As compared with the areas for the thigh movements some hemispheres show a greater leg area (hemispheres 1R, 2R, 3R, 3L and 5R) while others (1L, 2L and 4R) show a lesser leg area. The general distribution of the areas does not differ markedly for these two segments, although the forms of the areas are not nearly the same. Both thigh areas and leg areas are located at the upper portion of the fissure of Rolando with perhaps a little more extensive advance towards the lower portion on the part of the leg area. Most of the points in both areas, as can be seen by placing the two figures together, are duplicates, indicating that the movements are combined movements of thigh and leg. In a few cases, especially in hemispheres 1R and 3L, the leg movements were not combined with movements at the thigh.

The percentage relations of the two hemispheres of the same animal and those of the average areas in the five animals are very great. It will be noticed that the relation R/L varies from

TABLE IV. Measurements of the extents of leg areas. The figure marked with an asterisk is probably too low (see page 91) and the corresponding percentage R/L too high.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	25.5	16.5	56.5	89.0	20.5	*30.5	16.0	60.0	46.5
Percentages R/L	155		63		67		—	129	
Percentage relations of averages, Monkey 2 = 100.	29		100		35		22	74	

63 to 155 per cent. The percentage relations of the average extents of the areas with the extents of the areas in monkey 2 as unity are also greatly different, ranging from 22 to 74. In no case do these proportions correspond with the proportions for the thigh areas, the nearest approach to correspondence being in the case of monkey 5. It can be concluded, therefore, that neither the absolute nor the relative extents of the areas for the thigh and leg movements closely correspond.

Foot.—Variations, both for absolute and relative amounts of the areas, similar to those which have already been described for the thigh and leg are also noticed for the foot areas. These are shown in the diagrams of Figure 5 and in Table V. These variations exist not only for the different animals but also for the two hemispheres of the same animal. In the latter cases, however, the correspondence is closer than in the former. If we take the net totals as standards, that is, if we take the combined stimulable zones for the arm and leg segments as standards for each hemisphere, we find that the percentages of the areas

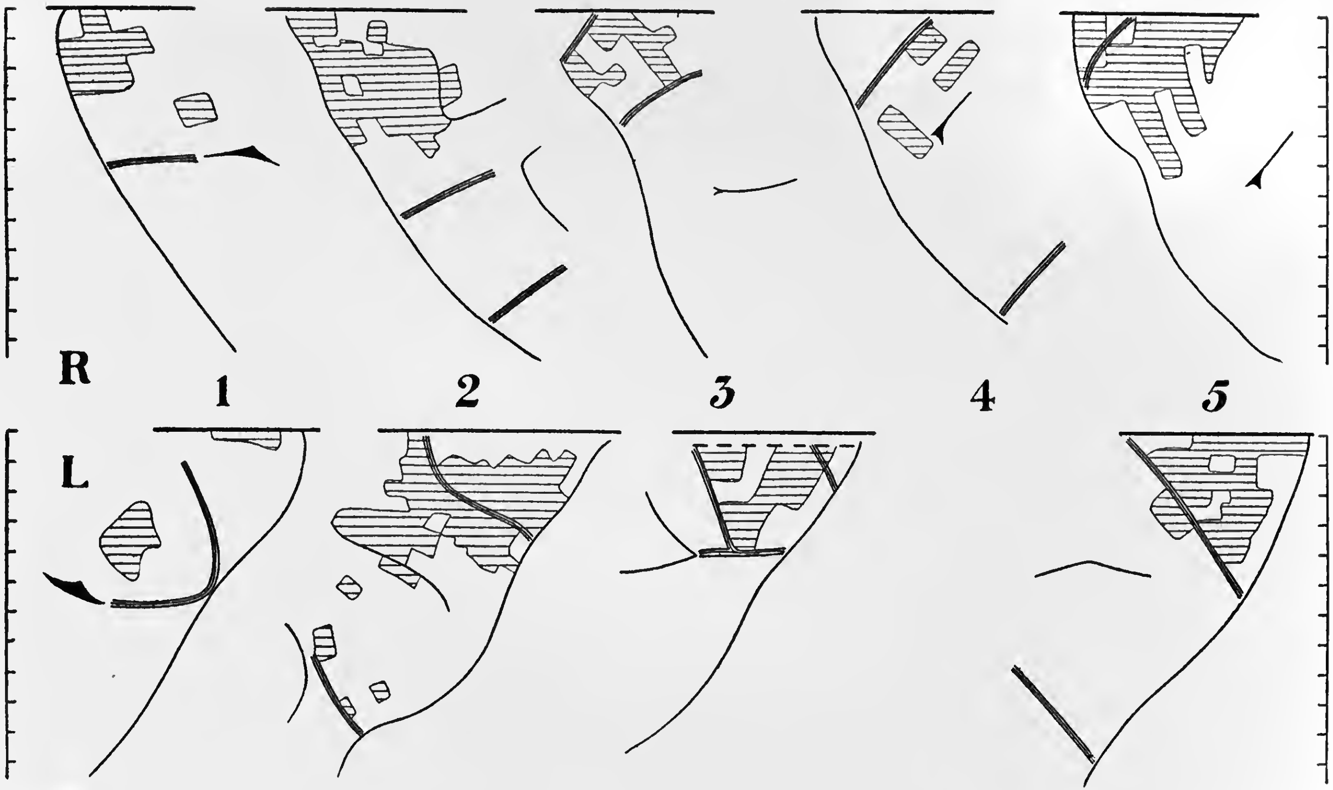

FIGURE 4. The extents of the cerebral stimulable areas for the leg. Designations the same as in Figure 2.

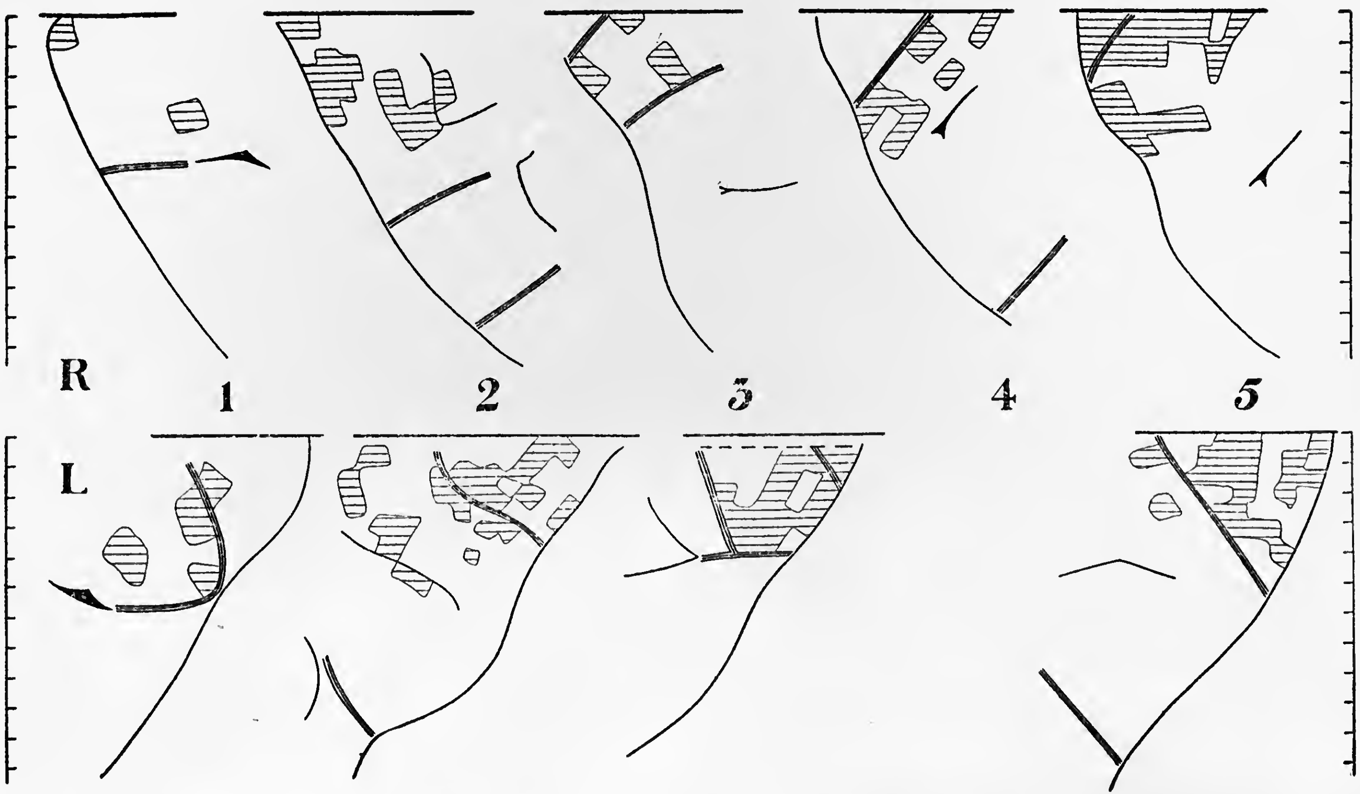

FIGURE 5. The extents of the stimulable areas for the foot. Designations the same as in Figure 2.

TABLE V. Measurements of the extents of foot areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	9.0	23.0	34.5	52.5	13.5	35.0	24.0	50.5	42.0
Percentages R/L	39		66		39		—	120	
Percentage relations of averages, Monkey 2 = 100.	37		100		56		55	163	

for the foot movements for the two hemispheres of one animal vary in two cases (monkeys 1 and 3) and do not vary greatly in the other two cases (monkeys 2 and 5). In relation to the standards which have just been mentioned we find the foot areas with the following per cents: 1R = 8; 1L = 15; 2R = 23; 2L = 25; 3R = 11; 3L = 27; 4R = 31; 5R = 36; 5L = 29. In other words the total extents of the areas governing the movements of the foot vary from 9 per cent. (1R) to 36 per cent. (5R) of the total areas for arm and leg. These percentage data do not correspond closely with the actual extents of the areas, which vary from 9 sq. mm. (1R) to 52.5 sq. mm. (2L). Nor do the relations R/L of actual measurements have the same proportions and the same serial order as the relations R/L of the percentages of the totals. This failure of correspondence is due, of course, to the varying degree of overlapping areas in the different hemispheres. The overlapping of areas does not entirely change the relative positions of the different hemispheres, however, for hemisphere 1R still remains the lowest, followed by 3R. The position of 4R is, however, considerably changed in that by this comparison it shows a relatively large area for foot movements whereas in absolute amounts it is the fourth lowest.

Comparisons of the areal amounts for the foot with those for

the thigh and the leg show many interesting relations. In the brains of monkeys 2 and 5 the foot areas are less than either the thigh or leg areas, although in both hemispheres of monkey 5 the superiority of the thigh over the foot is small and, perhaps, within the error of calculation. In 3R a similar relation holds, although on the left the reverse condition is found. In monkey 4 and in monkey 1 the relation is not constant, the thigh area being larger than the foot area in 1L and less in 1R and in 4R.

The figure illustrating the distribution of the foot areas in the different hemispheres shows other interesting variations. In a number of cases we find that, unlike the corresponding areas for the thigh and for the leg, there has been a sort of diffusion or scattering of the foot areas. The diagrammatic representation of the points of stimulation shows less of a coalesced mass and more individual patches. Whether or not this has any anatomical or physiological significance cannot be determined. A similar condition will later be noted for some of the areas for the arm segments.

Another matter which may be called to the attention of the reader is the occurrence of points or areas for "pure" movements of the foot. A careful comparison of figures 3, 4, and 5 shows that there are certain points in the foot area which have no overlapping of thigh and leg areas, and a further comparison with figure 6 shows a similar state of affairs as related to toe movements. Thus we find in 1R a small area, at the upper portion of the fissure of Rolando which borders upon the longitudinal sulcus, which is not duplicated in any of the other three diagrams for the leg movements in this hemisphere. Also in 1L there is a similar zone at the angle of the large blood vessel, and a second zone at the extreme upper portion of the area. Similar zones are found in four other hemispheres; in 4R at the extreme right upper portion, in 5R a small area in the lower part of the solid, in 5L another zone bordering upon and equidistant from the indicated extremities of the blood vessel and towards the fissure of Rolando, and in 3L a zone of this character at the left end of the solid area. It will thus

be seen that scattered throughout the solid area for the leg there is found an occasional zone for movements of one portion of the anatomical segment uncomplicated with movements of other segments.

Toes.—The relative positions of the toe areas is noteworthy. A comparison of the diagrams in Figure 3, 4, 5, and 6 shows the toe areas in 1R to be higher[6] than the thigh area and in general higher than the foot area but closely approximating the leg area. In 1L the area is massive and lies nearer the longitudinal sulcus, the thigh area, with the exception of a few points, lying lower in the field. For 2R and for 2L similar statements cannot be made, for in general the toe areas of these animals lie lower down than the areas for thigh and foot, although they approach in location the area for the leg movements. It should, however, be noted that in these hemispheres points lying much lower down than that corresponding to the toe area were found for the thigh and leg movements. In 3R the total extensity of the toe area is much less than that for any of the other leg elements but the area is apparently just as widely spread over the cerebral convexity. In 3L the area is greater than those for the other segments and to a slight degree it is more widely spread. In 4R the area is much greater and extends higher and farther backwards than the other areas. In 5R the area is the least extensive of the four leg segments and it is, unlike that for the foot and that for the thigh, compact. 5L is also an area without divisions and is more compact but only slightly smaller than the other three areas for the leg.

It is to be noted, therefore, that differences exist not only with respect to the absolute and the relative sizes of this area in the different hemispheres but also with respect to the diffusion or compactness of the area.

At the same time mention may be made of the variations which are similar to those which have already been described for the other leg segments. We find the absolute amounts of

[6] "Higher" and "lower" here refer to the diagrams, and these terms correspond to the anatomical, but more cumbersome, "nearer the longitudinal sulcus" and "farther from the longitudinal sulcus" respectively.

the areas differing in the different animals, and at the same time differing in the two hemispheres of the same animal. Moreover we find the relative amounts of the areas widely different for the different animals and for the two hemispheres of the same animal. In this respect there is an agreement with the other areas which have previously been described. In 1L, 3L, and 4R the toe areas exeed those for the thigh, for the leg, and for the foot; in 2R, 2L, 5R, and 5L the toe areas are exceeded by those for the other hind limb segments, although the excess in the case of 5L is slight and well within the observational error. The variations in totals are not as great as those which have been noted for the other leg segments, nor do the percentages in relation to the total stimulable areas vary as much. The hemisphere to hemisphere variations, with the exception of those of the brain of monkey 5, are considerable and differ in some cases by as much as 1 to 2.5. The results, diagrammatic and numerically, are given in Figure 6 and in Table VI.

Shoulder.—The totals of the shoulder areas range from 11.5 sq. mm. (4R) to 80.5 sq. mm. (2R), with percentages in relation to the net totals (leg and arm segments together) ranging from 15 (4R) to 54 (3R). The differences in amount of the

TABLE VI. Measurements of the extents of toe areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	24.0	51.0	20.5	52.5	16.5	45.0	33.5	37.0	41.0
Percentages R/L	47		39		37		—	90	
Percentage relations of averages, Monkey 2 = 100.	103		100		84		92	168	

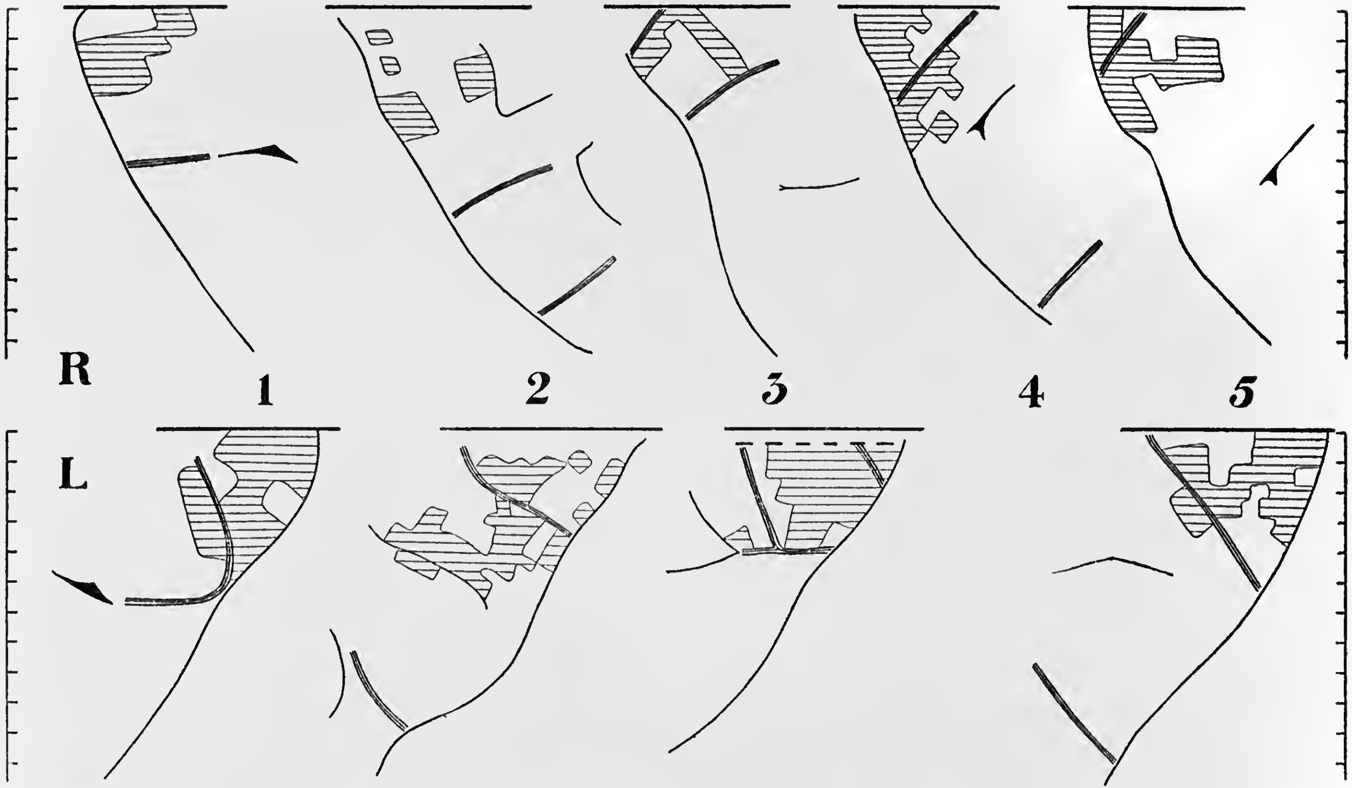

FIGURE 6. The extents of the cerebral stimulable areas for the toes. Designations the same as in Figure 2.

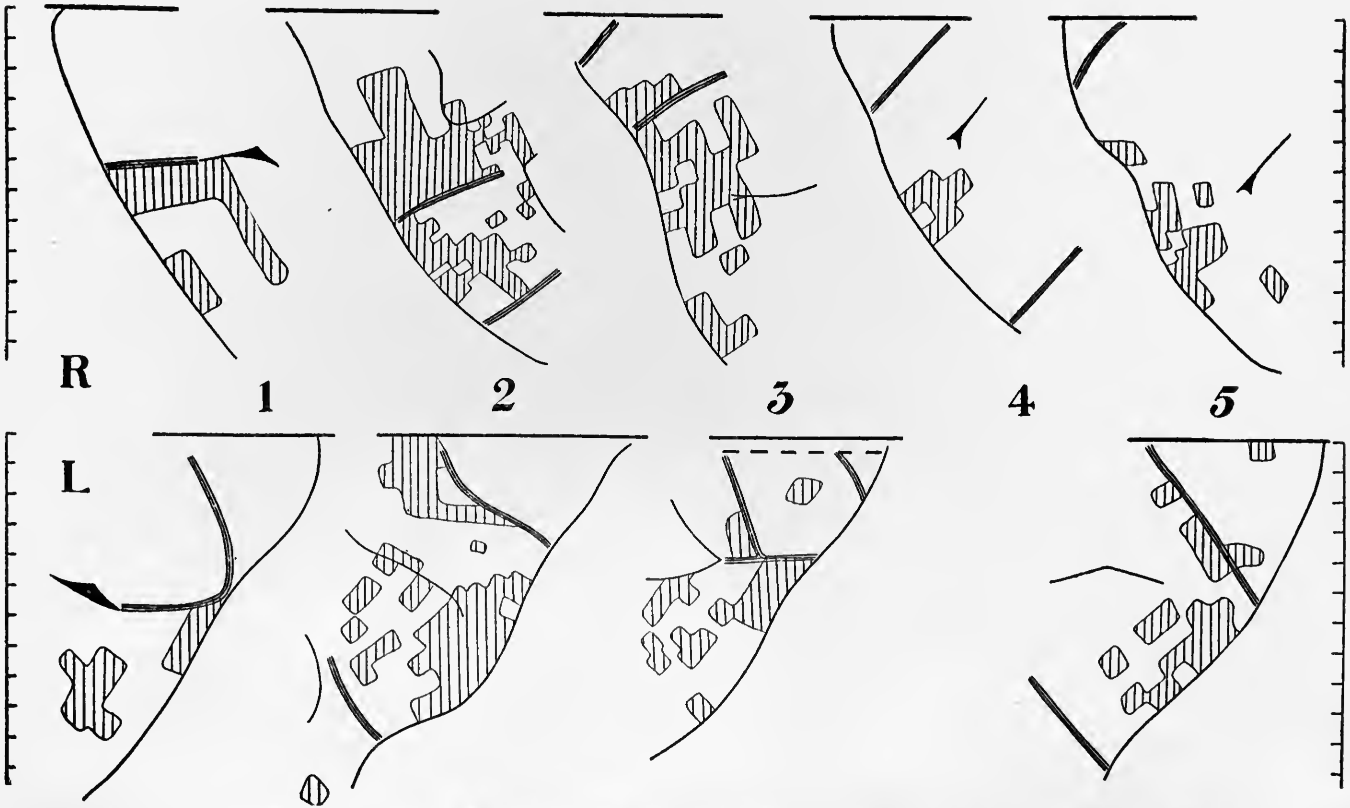

FIGURE 7. The extents of the cerebral stimulable areas for the shoulder. Designations the same as in Figure 2.

TABLE VII. Measurements of the extents of shoulder areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	37.0	25.0	80.5	79.5	67.5	32.0	11.5	26.0	48.0
Percentages R/L	148		101		211		—	54	
Percentage relations of averages, Monkey 2 = 100.	39		100		62		14	46	

areas in the five animals are greater than in any previous area and also greater than any of the areas for the other arm segments. The amounts and the illustrations of the distributions of these areas are shown in Table VII and in Figure 7. In relation to the four leg segments which have already been considered there are four hemispheres in which the shoulder area exceeds each of the leg segment areas (1R, 2R, 3R, and 5L), there are two hemispheres in which the shoulder area is less than each of the leg segment areas (4R and 5R) and three hemispheres in which two of the leg segment areas exceed and the other two are less than the shoulder areas.

The variations from hemisphere to hemisphere parallel those which have already been discussed for other segments, the greatest difference being found in monkeys 3 and 5, where the differences are approximately 100 per cent.

In addition to the differences which have been mentioned, the wide-spread distribution of the shoulder areas, especially in hemispheres 2L, 3R and 5L, is noteworthy. At the same time the discreteness of the zones is a prominent feature in the illustrations. There is also to be noted the relation of the areas to the central fissure. In regard to this it will be observed that the areas have the same general features as do those for the thigh movements in that some of them appear to be outcropping

or projections from the concealed fissural areas, whereas others are less apparently related to those hidden areas. At the same time in some hemispheres there is an apparent sharp definition of the areas by the principal blood vessels and by fissures other than that of Rolando. While from the facts now at hand it cannot be said that these divisions by fissures and by the principal blood vessels have any special physiological significance the finding of this in relation to several areas gives an indication that these landmarks may have some physiological as well as anatomical meaning. An examination of all the diagrams is suggestive of this conclusion, but the matter needs a more extensive and a more careful study with a definite question in view.

Forearm.—The apparent outcropping of the zones for the forearm from similar areas located within the infoldings of the fissure of Rolando is more noticeable than in any other previously considered segment. In every hemisphere there is a considerable extent of forearm area bordering upon the central fissure and moreover the areas appear more solid than those for the shoulder movements. This does not mean, however, that the phenomenon of diffusion is lacking for in fact an examination of the diagrams of Figure 8 reveals a marked degree of separation of the areas in 2R, 2L, 3R, and 5R.

Table VIII gives the measurements of these forearm areas

TABLE VIII. Measurements of extents of forearm areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	55.0	56.0	89.5	92.5	80.5	63.5	24.0	54.0	52.5
Percentages R/L	98		97		127		—	103	
Percentage relations of averages, Monkey 2 = 100.	61		100		79		26	59	

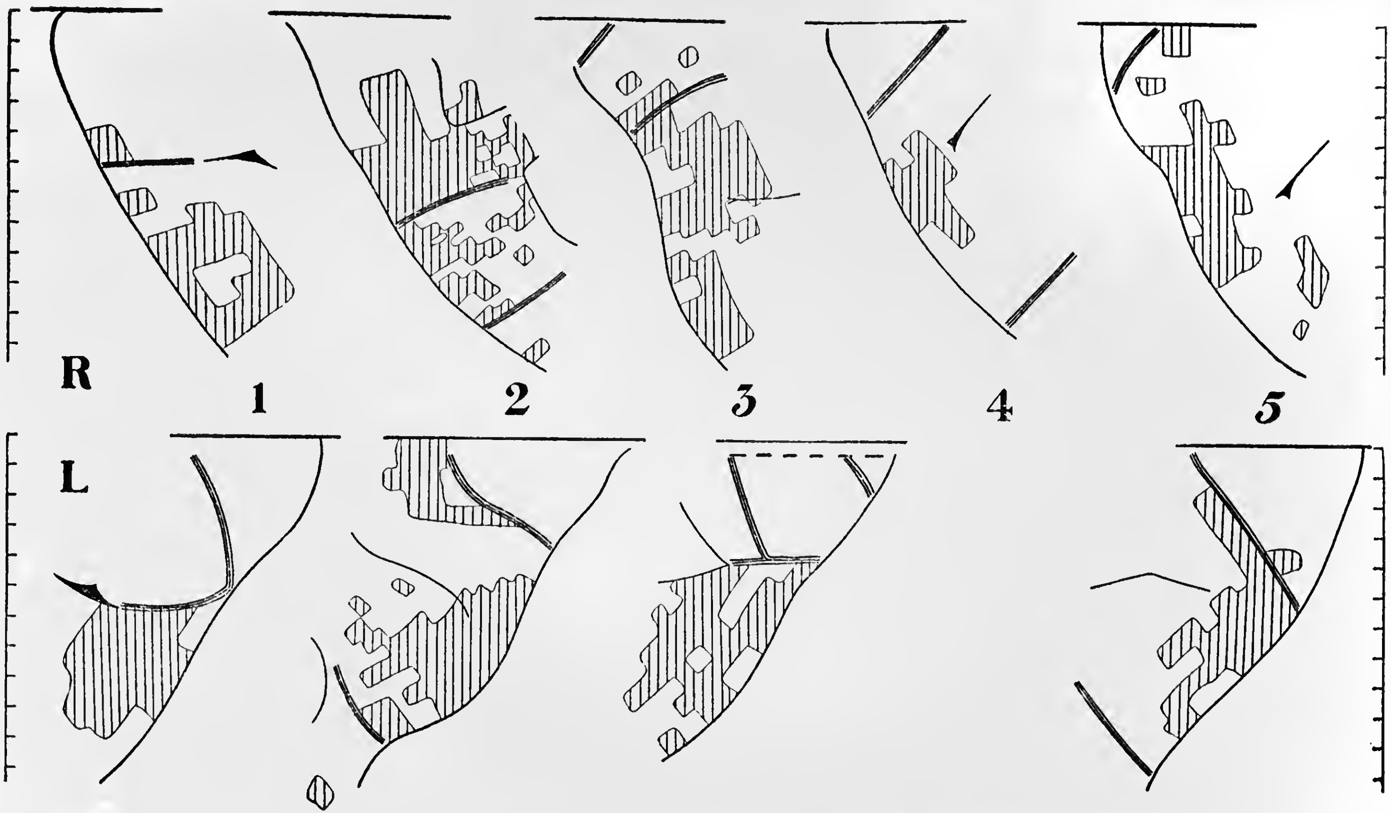

FIGURE 8. The extents of the stimulable areas for the forearm. Designations the same as in Figure 2.

in the nine hemispheres. Here are shown almost as great differences as have been shown to exist for the other areas already dealt with, for in one case (monkey 4) we find the area only about one-quarter the size of that in monkey 2. In two animals (monkeys 1 and 5) the areas are not only nearly equal but the two hemispheres are also approximately of the same size. This is the closest correspondence which is to be found in the whole series but I hesitate to conclude that it has any great significance.

In three animals the proportions R/L are nearly equal (monkeys 1, 2 and 5) which again is a condition not found for any other area, but which I also doubt has any well marked significance. The reason for this is to be sought in the varying relations of the extents of these areas to the net total (leg plus arm segments) areas. When this comparison is made it is to be observed that no close correspondence exists except for the two hemispheres of monkey 5. By this comparison the two forearm areas of monkey 1 differ by 25 per cent., those of monkey 2 by an almost equal amount, and the differences in the relations of the hemispheres of monkey 3 are also approximately equal.

Hand.—The data regarding the extensions of the areas controlling movements of the hand are given in Table IX and in Figure 9. Unlike many of the areas which have previously been considered these areas are not massed but are widespread

TABLE IX. Measurements of extents of hand areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	39.0	39.5	42.0	58.5	37.0	18.5	11.0	32.0	16.5
Percentages R/L	99		72		200		—	193	
Percentage relations of averages, Monkey 2 = 100.	78		100		55		22	48	

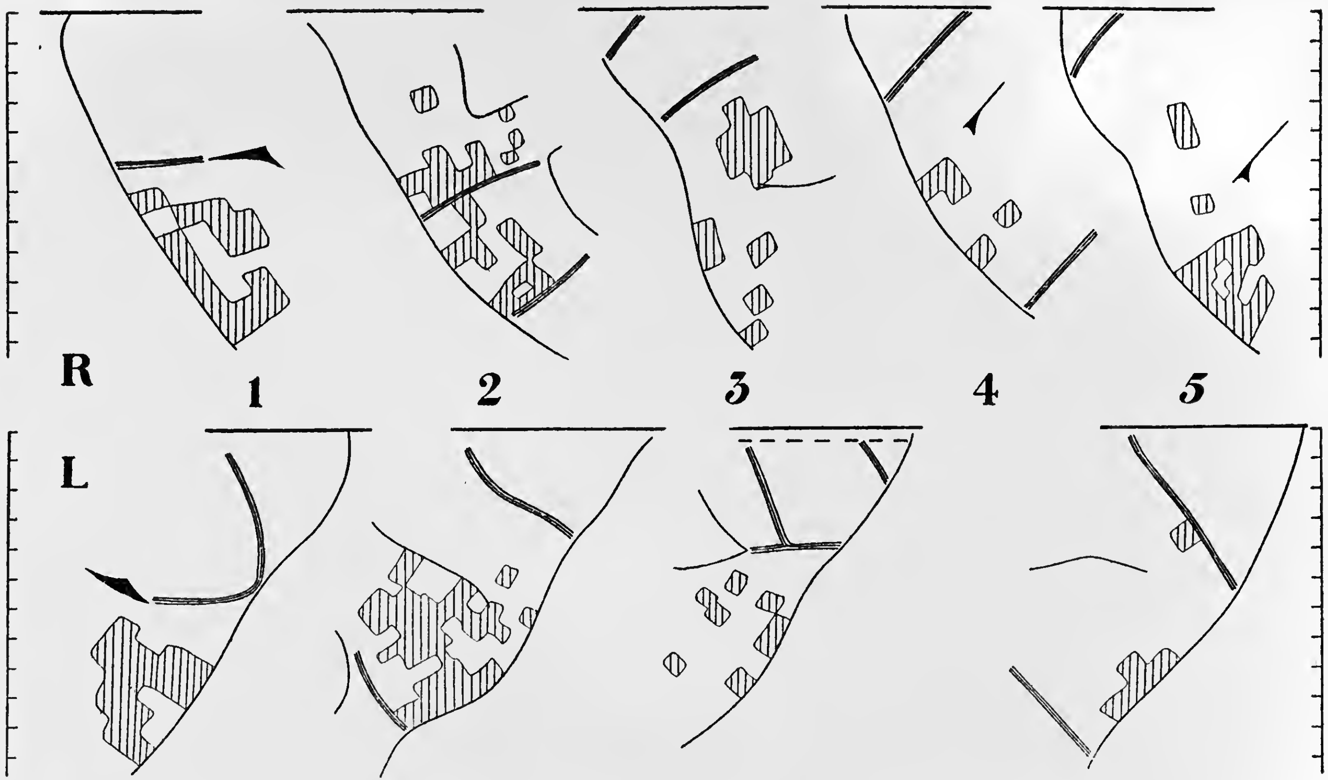

FIGURE 9. The extents of the stimulable areas for the hand. Designations the same as in Figure 2.

and divided relatively more than any of the leg segment areas and the arm segment areas with the exception of those for foot movements. The average extent of this area for all hemispheres (32.7 sq. mm.) is less than that of the other segment areas with the exception of the foot areas (average 31.7 sq. mm.) and the variations are considerable. Although the average extent of this area is among the smallest it has wide variations, for in monkey 1 it is exceeded in each hemisphere by but two of the other areas, in monkey 2 it is exceeded in each hemisphere by four other areas, in monkey 3 it is exceeded on the right by three areas but on the left by six areas, in the one hemisphere of monkey 4 it is exceeded in extent by seven areas, and in monkey 5 on the right by seven areas and on the left by all other areas.

The variations in absolute size in different hemispheres are great, from 11 (4R) to 58.5 sq. mm. (2L), a ratio of 1 : 5.3. Its relation to the net total is less variable, from 11 (5L) to 34 (1R), although the ratio is slightly greater than 1 : 3. In only one animal (monkey 1) are the areas for the two hemispheres nearly equal in size, although in relation to the net totals the equality is greater in a second animal (monkey 2).

The percentage relations of R/L show only one instance which has previously been considered (shoulder area of monkey 3) in which the difference is as great as is found in monkeys 3 and 5 for the hand areas. These figures should, however, be considered to be no more than suggestive for in many previous cases (for example, thigh areas of monkeys 1 and 2, foot areas of monkey 1 and 3, toe areas of monkeys 1, 2 and 3, etc.) if the reverse percentages L/R had been used as a basis of comparison the differences would have been much greater in these other hemispheres.

The apparent punctiform character of the area under consideration is obvious in a number of the hemispheres. Although exceeded in size in most instances by the other areas the number of divisions greatly exceeds those for the leg and toes, slightly exceeds those for the thigh and fingers, and is exceeded only slightly by the foot and forearm areas and to a greater degree

by the shoulder areas. For such a relatively small area this wide-spread distribution is noteworthy.

In form the areas under consideration are widespread, the scattering being such as to make the different hemispheres appear to be without resemblance, and this statement is true for the two hemispheres of the same animal as well as for the hemispheres of different animals. The relation of the areas to the central fissure is not constant, not more than one-half of the areas in the nine hemispheres having close association with this fissure. With the exception of a slight relation to a subsidiary fissure in 2L the areas do not appear to bear a close relation to the other fissures and principal blood vessels, and to employ again the figure of speech which has previously been used it may be said that most of the cortex which responded with movements of the hand appears to be outcroppings from the depths or upward projections from possible underlying areas.

A comparison of the total areas in Table IX with those in Tables VII and VIII shows that in all hemispheres the hand area is less in extent than that for the forearm and in monkeys 2 and 3 less than that for the shoulder, but in monkey 1 it is greater than that of the shoulder area while in monkeys 4 and 5 the relations are irregular or undecided.

If the data which have been given were to be interpreted in a manner which is not infrequent we might conclude from the relative measurements that in general the hand of these monkeys has only the same amount of cerebral control as the foot, but that in specific instances the hand has a greater amount of cerebral control and in other cases the foot is the part best represented in the cortex. Such a conclusion appears to me obviously premature, for even though it may prove to be true, at present we do not know exactly what cortical stimulability means and I believe we should not conclude from a comparison of two sets of measurements that we are dealing with information regarding lesser or greater cerebral control. The movements of the hand areas, it will later be noted, are more often associated with movements of the other arm segments than are those of the

foot with the other leg segments, and the matter of greater or lesser cerebral control appears to me to be bound up with the character of the distribution as well as with the superficial extents of the areas from which such movements may be produced by stimulation methods. It seems to me, therefore, that the element of complexity is an important factor, and that the question of the greater or less control should be considered only in the light of all the data for all the segments.

Fingers.—Figure 10 and Table X contain the results relative

TABLE X. Measurements of extents of finger areas.

Monkeys	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Areas in square mm.	55.5	15.0	40.0	57.5	41.0	46.5	10.0	35.5	40.5
Percentages R/L	370		70		89		—	88	
Percentage relations of averages, Monkey 2 = 100.	72		100		90		21	78	

to the areas for finger movements. Although some of these areas are smaller than the corresponding areas for the hand they average about fifteen per cent more than the latter. In only a few cases are the differences great enough to warrant note, the variations in hemispheres 1L and 3L and 5L being the greatest.

The comparative range of the areas for all hemispheres is approximately 1 : 6, which is nearly the same proportion obtained for most of the areas which have previously been dealt with. The diagrams of Figure 10 show the closer relation of the areas to the central fissure than is to be found with some of the other areas, since comparatively large portions of this area border upon this fissure. This, in other cases, has been considered to be an indication of the possibility that large or small cortical areas

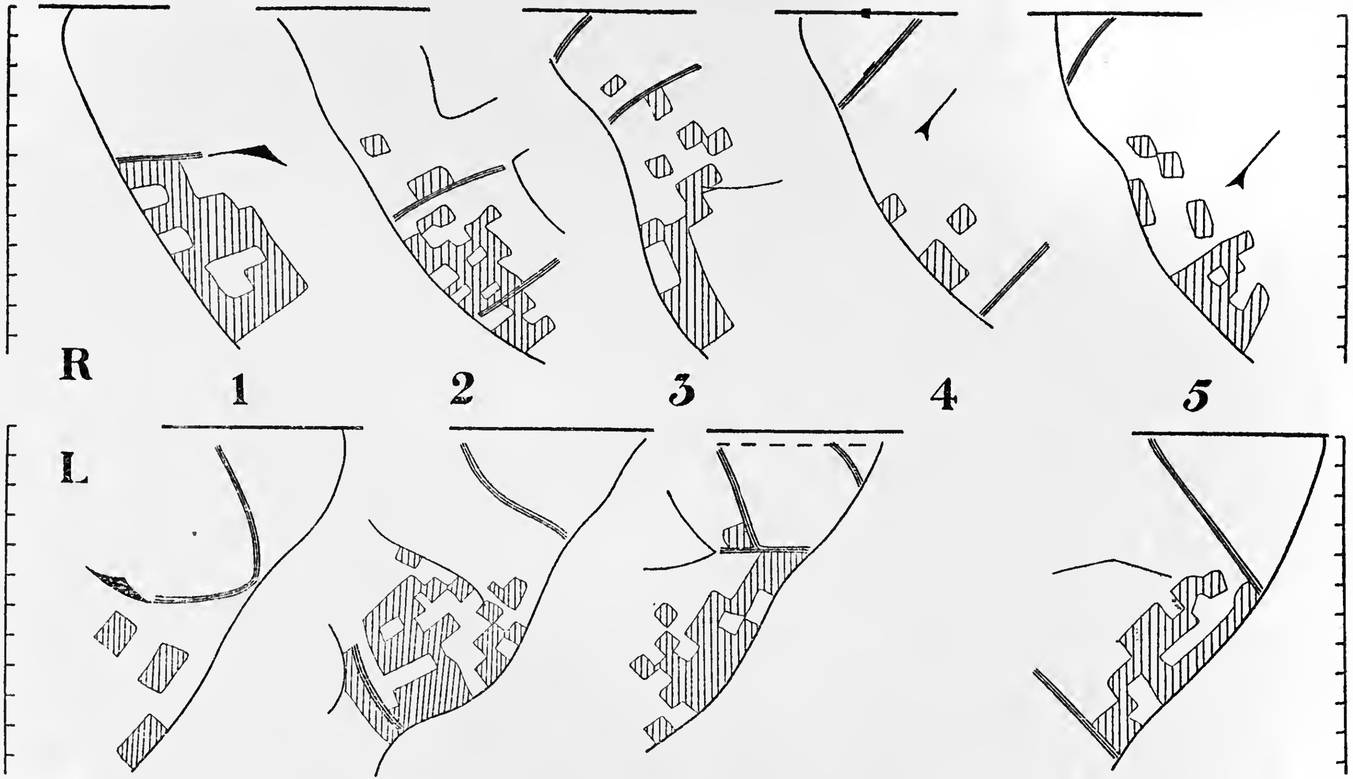

FIGURE 10. The extents of the stimulable areas for the fingers. Designations the same as in Figure 2.

for such movements may be concealed within the Rolandic fissure. If this be true the sizes of the finger areas would be much greater than those which are shown in the diagram and in the table.

General.—For purposes of comparison I think we are justified in combining the totals of the stimulable areas regardless of overlapping, especially since these totals in relation to the net totals will give some indications of the extents of the overlappings from area to area, and consequently they also give indications of the complexities of the movements of the different hemispheres. The general relations are shown in Table XI. In this table

TABLE XI. The overlapping of areas for the leg and arm segments. The totals of all areas were obtained by adding the totals for each hemisphere, and the amounts of overlapping by subtracting from these figures the "net totals" given in Table II.

	1		2		3		4	5	
Hemispheres	R	L	R	L	R	L	R	R	L
Totals of all areas	249.5	256.0	411.0	589.0	294.0	287.0	155.0	348.0	333.0
Net totals	115.0	157.0	152.0	215.0	124.0	132.0	78.0	139.0	144.0
Overlappings	134.5	99.0	259.0	374.0	170.0	155.0	77.0	209.0	189.0
Per cent. overlappings in relation to net totals	117	63	170	174	137	117	99	150	131

are shown (*a*) the totals of the areas which have been considered, that is the sum totals of the thigh, the leg, the foot, etc., areas for all nine hemispheres, (*b*) the net totals, that is the amount of superficial space covered by the areas, (*c*) the differences between these sets of figures, which give the total amounts of overlapping of the individual areas, and (*d*) the percentage relations of the amounts of overlappings to the net totals of the hemispheres. It is obvious that if the series of stimuli on one hemisphere produced a combined movement of all the segments which we have been considering there would be a total of over-

lapping amounting to 700 per cent of the net total for that hemisphere, because each of the segments would be totally represented in the grand total. The greater percentage of overlapping is, therefore, an indication of greater complexity of movement. In the next section we shall deal with the special overlappings of the arm segments in the leg area and of the leg segments in the arm areas and here we shall confine ourselves to the consideration of the special overlappings of the arm segments among themselves and of the leg segments among themselves. This includes at the same time the borderline overlappings, since these border areas cannot be considered to be distinctively either arm or leg areas.

The smallest amounts of overlapping was found in 4R and in 1L, the greatest in 2L and in 2R. The differences in this respect range from 77 to 374 sq. mm., or approximately 1 : 5. In relation to the net totals, probably a fairer means of comparison of the individual hemispheres with one another, the range is from 63 to 174 per cent, or approximately 1 : 3. An interesting fact is that in 1R, in which it has been noted (p. 96) that no overlapping of leg and arm areas occurred, the total amount of the overlapping exceeded that of 4R, in which leg-arm overlapping was found, and the total amount of the overlapping is not markedly less in 1R than in 3L in which the amount of overlapping of the leg and arm segment areas is considerable. At the same time the percentage relations give equally interesting figures regarding the same thing, for it is to be observed that the percentage of overlapping in 1R is greater than that of 4R, equal to that of 3L and is not greatly exceeded by that of 5L, in all of which hemispheres the amount of overlapping of the leg-arm areas is not especially small. This indicates that in hemisphere 1R there has been a more general complexity of movement for the two segments we have considered than for the other hemispheres just mentioned since a certain percentage of the overlappings in the other hemispheres is due to combinations of arm and leg movements. The low percentage in 1L may be considered a typical example of what may be expected when the two segments have not overlapped.

The complications or the combinations of movements are also

shown by the number of cases in which the areas for one segment overlap those of the other segments. These data for the leg segments are shown in Table XII and those for the arm segments

TABLE XII. Overlappings of leg segment areas. Digits represent the numbers of hemispheres in which overlapping occurred. The total possibilities are nine in each case.

Segments	Toes	Foot	Leg	Thigh
Toes	—	8	8	7
Foot	8	—	9	9
Leg	8	9	—	9
Thigh	7	9	9	—

in Table XIII. In these tables there are shown the total numbers

TABLE XIII. Overlappings of arm segment areas. Digits represent the numbers of hemispheres in which overlapping occurred. The total possibilities are nine for each case.

Segments	Shoulder	Forearm	Hand	Fingers
Shoulder	—	9	9	8
Forearm	9	—	9	9
Hand	9	9	—	9
Fingers	8	9	9	—

of cases in which overlappings occurred, not the individual points in the areas, and consequently not the totals of the areas or the total portions of the cortex representing the areal distribution of movements of the segments. If one area, for example that of the shoulder, should have an overlapping in all hemispheres it is clear that the table would show a total overlapping in nine hemispheres. Similarly for the other segments. When the number is less than nine, it means that in one or more hemispheres at no time in the whole series of experiments upon those hemispheres did combined movements of the two segments occur. The tables show that in two cases (1R and 1L) there was no overlapping of the thigh and the toe areas, in one case (1R) there was no overlapping of the foot and toe areas, and in one case (1L) there was no overlapping of the toe and leg areas. In view of the fact that in 1R no overlapping took place of thigh

and toe, and foot and toe, the small percentages of overlapping is understandable, and this is the more noticeable also because of the failure to find from cortical stimulation in this animal combined movements of the arm and leg.

The almost universal overlapping in the arm segments areas indicates the general complexity of the movements which were obtained by the stimulation of the cortex in this area, and at the same time it shows that the complexity is found in all hemispheres with the exception of shoulder-finger relations of hemispheres 1L. It does not show, however, that there is the same degree of complexity for all other hemispheres, for to settle the latter matter there must be a comparison of the individual points which it is not possible to make at this time. It may be said, however, that there are considerable variations in complexity (hemisphere and animal) shown by the examination of the protocols of the individual tests, and these are partly indicated by the differences in the totals of overlappings which are shown in Table XI. It may be repeated that the results in Tables XII and XIII do not mean that there has been a total overlapping of all segments in all hemispheres for all the points which were stimulated. In fact from Table XI we can conclude that at the most (2L) there has been less than two-thirds of the total possible amount of overlapping and in most cases the amount of the overlapping is not more than two-sevenths of the possible total, and usually much less than this amount. If there were no overlapjpings of arm and leg segments and there was a complete overlapping of the areas for the individual parts of the segments, which would mean that when any motor point was stimulated the resulting reaction would be a movement of thigh + leg + foot + toes, or a movement of shoulder + forearm + hand + fingers, we should have a total overlapping of 300 per cent. A considerable amount of overlapping occurs in relation to the leg and arm segment areas so that the greatest recorded amounts (2L, 374 per cent) are made up of extra-segmental overlappings and of inter-segmental overlappings. Table II, column 6 (p. 98) shows the amount of extra-segmental overlappings, and the figures should be subtracted from those in Table XI. It should also

be remembered that the figures in Table II do not represent the totals of extra-segmental overlappings but only those of total-leg and total-arm, for such overlappings may be of two or more parts of each of the two segments (arm and leg) with which we have been dealing. When, however, the subtraction which is suggested has been made we find that there is a noticeable reduction in some of the figures in Table XI. At the same time it should not be thought that in dealing with the relation of the cerebral cortex to complexities of movement such subtractions should be made, for in general it is true that the greater the overlappings the greater is the degree of movement complexity.

Thus, stimulation of the cortex at the border of the two large areas produced complex movements of the two totalized segments. We found for example movements of all the arm segments towards the leg and at the same time complementary movements of the leg towards the arm. Such movements are well represented by those of the intact animal when he wishes to scratch his leg, but makes only part of the movement, that pertaining to the approach of the hand and fingers to the leg and a similar approach of the leg towards the hand so that the latter has a better chance for scratching. Also, such a movement as the transfer of food from the hand to the foot is of this complex type, and similarly with movements which simulate or resemble those of the simultaneous use of the arm and leg segments in the act of taking hold of the bars of the cage. Such movements are on the other hand not always simultaneus, not infrequently it was found that after the arm had made a definite movement the leg would make a movement succeeding that of the arm.

Summary.—The data show that in different animals and in different hemispheres a variety of distribution of the areas concerned with the movements of the individual segments of the leg and arm. In addition to this variation in distribution, variations in the total amounts of the different areas were found, which when averaged for all hemispheres show the forearm area of greatest size, with the foot area of the smallest average size, and between these extremes and in serial order the areas for

the shoulder, the leg, the thigh, the fingers, the toes, and the hand. It will be noticed that in all cases the average of a segment of the arm exceeded in areal size that of the corresponding segment of the hind limb, *i.e.,* the area for the shoulder movements was on the average greater than that for thigh movements, that for forearm movements greater than that for leg movements, etc. In the individual hemispheres such relations do not exist, in some cases the leg areas being correspondingly larger than the arm areas. At the same time the serial order for the segments is not the same for all animals, in one case the thigh area being the largest, in another hemisphere the forearm area being the largest, etc. The shapes of the corresponding areas in the nine hemispheres did not approximately correspond nor was there a correspondence of the spatial relations of the areas to such well marked anatomical landmarks as the central fissure, the longitudinal sulcus, etc. In a few cases the anatomical dividing lines appeared to have a certain physiological significance, but in other cases, and especially in relation to certain areas, this was not indicated. In all hemispheres excepting those of one animal there was found a greater or less overlapping of the areas for the leg and arm segment movements, which was shown by the production of combined reactions of these segments. In all hemispheres without exception there were found overlappings of the areas for the individual segments of the leg and arm, which was shown by the complex movements of these parts. These overlappings varied in all hemispheres, by which is meant that the stimulation of the cortex of some hemispheres resulted in more of the complex movements than did that of others.

IV. ANOMALOUS DISTRIBUTIONS OF THE STIMULABLE AREAS

Arm movements within the leg areas.—In the broadest sense we may consider that the leg segment area is that area within which stimulation produces leg movements, and the arm area that area within which stimulation produces arm movements. Taking this definition of the areas we should need to consider that the leg areas or the arm areas are not massed but are spread over the precentral cortex as widely as the zone in which a stimulation at any point produces such movements. For a better limitation of the areas we must not deal with the widely spreading areas in this manner, but limit the designation of the individual areas to those solid-like combinations of zones in which the special character of movements are uniformly or nearly uniformly obtained. By thus dealing with our results we can say that in general there is a leg area separate and distinct from, but contiguous to, the arm area, and that there is a similar arm area, but that between the two areas there is an intermediate zone which is allied to both, or which is both, and which can be considered to be a combined arm and leg area.

By the limitation or the definition of the areas in this manner we find that there remain certain areas or points within each of the principal areas which are associated with the production of movement of another segment separate from the segment with which the area has definite connections. Thus we find that arm movements are sometimes produced by the stimulation of areas which are enclosed on all sides by zones which are distinctively leg movement areas since only leg movements are produced by the stimulation of the cortex in these regions and at the same time there are arm areas within which stimulation sometimes produces leg movements. These areas are different from the bordering areas in that the results are unlike those for the surrounding zones, and are therefore to be considered anomalous, while the bordering areas are "normally" the combinations which are expected in view of the continuity of the whole stimulable zone.

An examination of Figure 2 shows that there are no bordering combination areas in the hemispheres of monkey 1 but that such areas are found in all the other hemispheres. It will also be observed that there are no anomalously distributed areas in the hemispheres of monkey 1 and none in 2R, but that the other six hemispheres show anomalous areas. In 2L we find an area of this character with a considerable extensity having its upper border contiguous to the longitudinal sulcus and extending downwards towards the fissure of Sylvius along the principal blood vessels which is illustrated in the diagram. We also find in this hemisphere a small area which is related to arm movement control, for movements of the shoulder were produced by the stimulation of this area although the stimulation of the same points gave leg movements and the stimulation of the surrounding areas also gave purely leg movements. Similar zones were found in the hemispheres of monkey 3; on the right at the extreme frontal border of the area points were found the stimulations of which were followed by movements of the forearm as well as of the leg segments, and on the left side a similar zone in the center of the leg area the stimulations of which produced simultaneous movements of the segments of the leg and of the shoulder. In monkey 5 there were also found on the right side a combined area bordering upon the longitudinal sulcus which stimulations showed was associated with the production of forearm movements as well as with leg movements, and a second area somewhat lower in the field which gave similar combinations of forearm and leg movements, in the left hemisphere of this animal the combined area bordering upon the longitudinal sulcus gave movements of the shoulder in addition to the leg segment movements which were noted in the protocol of the experiment as follows: "extension of toes, followed by extension of the leg and thigh, and a movement of the tail to the right, with a mass movements of the arm such as is made when lifting the shoulder."

The general results regarding the amounts of overlappings of the arm and leg segment areas are shown in Table XIV. This table shows only the general view of the relations as indicated by the overlappings of the different areas, without considering the

TABLE XIV. Overlapping of leg and arm segment areas. Digits represent the numbers of hemispheres in which overlapping occurred. The total possibilities are nine in each case.

Segments	Toes	Foot	Leg	Thigh
Shoulder	3	4	4	5
Forearm	4	4	6	5
Hand	1	2	3	3
Fingers	0	0	2	2

spatial character of the overlappings. Thus, for example, the total number of possible overlappings is nine in each case, and we find that in no case do we get an overlapping of the toe area onto the finger area, that in general the segments close to the trunk show the greatest number of overlappings, both with respect to one another and also with respect to the more peripheral segments. This would indicate a possible closer relation of the thigh movements and the movements of the hand and fingers, and a possible closer relation of movements of the shoulder with movements of the foot and toes. Until the movements are analyzed to a greater degree than is done at this time this can be taken only as a suggestion.

Leg movements within the arm areas.—The number of anomalous movements of this character is less than that of the arm movements in the leg areas. In 2L, on the outer border of the arm area, there is a small area the stimulation of which produced movements of the thigh and of the leg, and at the frontal edge of this area the stimulation was followed by knee flexions independent of any movement of the parts of the arm segment. At the lower portion of the arm area, far removed from the main mass of the leg area, two small areas were discovered which gave movements of the thigh and leg as well as movements of the arm segments, in one case the leg movements being combined with movements of the hand and fingers and in another case with movements of the forearm. In 4R thigh and leg movements were found to accompany stimulation of the area in the central portion of the large arm area where the latter bordered upon the fissure of Rolando.

Only two hemispheres, therefore, showed the presence of leg movements within the arm areas while five hemispheres of the total of nine showed arm movements within the leg areas. Although it is not possible at this time to determine the import of these variations it appears probable that they indicate a greater degree of ease of liberation of the arm movement impulse or a greater degree of complexity of arm connections. Allied to the results which have been considered in the preceding paragraph similar results were obtained which indicate the complexity of these movements and of the movement control. In 3R head movements in combination with movements of the shoulder were obtained by the stimulation of the cortex at the uppermost part of the arm area although the characteristic area for head movements lies lower in the field, approximately below that for the arm segments. In the same hemisphere head movements were found to follow the stimulation of the area close to the bifurcation of the subsidiary fissure which is shown in the diagram. This is far removed from the principal head area. At the same time mention may be made of the fact that in 4R the stimulation of the area which is shown as a blank space bordering upon the fissure of Rolando, and which is surrounded by arm areas, also gave movements of the tail whereas in the other animals in which movements of this organ occurred they followed stimulations of the areas bordering upon or near the longitudinal sulcus.

Relatively non-stimulable zones.—In the diagrams of Figure 2 there are to be found blank spaces within the cross-lined areas, or separating the cross-lined areas. This indicates that these areas are unlike the surrounding areas in that they are non-stimulable or relatively non-stimulable. This was mentioned in a previous section (p. 84), where it was also said that when an apparent non-stimulable area was found the strength of the stimulating current was increased to see if the area was really non-stimulable. At times it was found that we were dealing with an area with heightened threshold because the increased stimulus produced characteristic responses similar to those of the surrounding regions, but at other times the increased stimulus did not produce any response. Whenever the latter was

found it was concluded that we were dealing with a silent or a relatively silent area on account of the fact that any further increase of current strength can be objected to on the ground that the spreading of the current is more likely to take place and to stimulate not only at the spot at which the electrodes are placed but also adjacent collections of cells. Some objection may be raised against the universal application of this method of determining the silent character of the areas, and I do not press the point at the present time although the conclusion appears to me to harmonize with a number of other facts which have previously been reported by others. Whatever explanation we may select for the findings, whether we consider them to be indicative of a non-stimulable character of the special regions or of a relative lowering of irritability, it is of special interest to note that similar phenomena were not observed in the results of the series of stimuli to all the hemispheres which were tested. At the same time in a comparison of the hemispheres for which this phenomenon was noted there is found great variation. Thus we note the leg area in 1R to be divided into smaller areas, which division is probably of the character described above although not obviously so. The amount of space covered by this dividing area is great in the case of 2R, and the relatively non-stimulable zone in this hemisphere almost divides the arm area into two separate areas. Fewer of these non-stimulable areas were found in the leg areas than in the arm areas, which may be an indication of a greater fixity or of a higher degree of exactness in the development for the former. In this connection the diagrams of the other figures are of interest since they show similar phenomena associated with the areas for the individual segments. It will be observed that in most of the diagrams of the arm areas (shoulder, forearm, etc.) these divisions occur and that they are less frequent in the leg areas. It may be expected that the divisions would be more evident in the arm segment areas on account of the multiplication of the blank areas in each of the diagrams, but a careful comparison of all the diagrams referring to the arm areas shows that the divisions are more numerous than those of the leg areas even when the non-stimulable zones that are common to all are omitted.

Summary: In the hemispheres which were investigated there was found a number of points, or areas, the stimulation of which gave movements unlike those of the surrounding regions. This was especially marked in some of the hemispheres while others showed none of this crossing or combination of control. The number of cases in which arm movements were found to be associated with the stimulation of leg areas, or arm movements associated with leg movements when the surrounding areas gave only leg movements, is greater than that of arm movements from the stimulation of leg areas. A number of non-stimulable or relatively non-stimulable zones were found surrounded by normally stimulable areas.

GENERAL DISCUSSION (THEORETICAL)

The results of these experiments lead to certain conclusions which have widespread application regarding the functions, or functional connections, of all portions of the cerebrum. It is apparent that in this area, which has very generally been considered to have neural connections directly (or indirectly through intervening neurones) with the efferent cellular elements in the spinal cord, there is not the definiteness of localization, and therefore of connection, which has been supposed. The fact that there is a variation in the extent of the leg or the arm area in different animals indicates that motor cells located in similar locations may send impulses in different directions. The fact that the stimulation of certain spatially located points in an area which usually gives rise to movements of the thigh may, for example, result in combined movements of the arm as well as of the thigh is also an indication of a complex mechanism. This becomes more evident when we realize that such combined movements are obtainable upon stimulation of the cortex of one animal and not when the cortex of another is stimulated (or if obtained in the second animal the combined movement differs in quality). Furthermore, although the data in regard to the differences of control from the two hemispheres of the same animal are not as complete as they might be, the facts from the four monkeys of which both hemispheres were investigated indicate that there is a considerable difference in the connections which are established from each hemisphere. All the varying results are, however, of interest in that they lead to rather definite theoretical conclusions and in that they lead to a better understanding of the variability in control which are evidenced by the normal behavior of different animals and by that of different individuals and of different races of man.

In connection with the results of the present series of tests, the results of the recent experiments of Brown and Sherrington (**3**)

on the reversibility of action of allied centers[7] in the cortex are of very great importance. These investigators found that in the monkey's cerebral cortex there were several centers, or groups of cells, the stimulation of which normally brought about flexion, and other adjacent groups or centers which, stimulation showed, were normally concerned in the production of extension movements. The stimulation of one of the flexion centers, it was furthermore found, would bring about a slight or medium degree of flexion, while that of another would produce an extreme degree of flexion. Similar results were obtained upon stimulation of the extension centers, or groups of cells. When, however, a flexion center was stimulated repeatedly it was discovered that the flexion reaction did not remain of the same intensity as that which was originally found. There were changes in the degree of the muscular contractions in a series of stimulations of the same cerebral spot and in certain cases flexion eventually was replaced by the opposed movement of extension. From the results of this experiment we see that the repeated stimulation of one area may result in a reversal of the function, such a reversal, however, being probably only an exaggeration due to the normal connections and perhaps only a magnification in certain respects of the normal functions of such a center. After pointing out this fact the authors conclude (page 277) that "the frequence of reversal as a phenomenon attaching to the reactions of points in the motor cortex suggests that one of the functions of the cortex may be the performance of reversals, and that the greater predominance of reversal under cortical than in purely spinal or decerebrate reflexes is because reversal is one of the specific offices of the cortex cerebri."

In the same series of experiments Brown and Sherrington also noted another result which is of great interest, namely the variation in the degree of activity accompanying the stimulation of the different centers at different times. When on the cortex of an ani-

[7] The term center in the discussion implies no metaphysical assumption. It is a convenient and short designation for "a collection of cells the stimulation of which may result in certain reactions and the extirpation of which may bring about certain deficiencies of activities or behavior."

mal the center for extreme flexion was definitely located (*i.e.*, spatially in relation to the other flexion centers) and the animal was permitted to recover for some hours before a second experimental determination of this center was made, it was discovered that the second determination of the point for extreme flexion did not always correspond with the point originally determined. In other words, repeated stimulation of the same center, or group of cells, did not always result in the production of the same quantity or grade of movement. Thus, the center which on the first stimulation gave the greatest amount of reaction might be found to give a less amount of reaction at another time and the area which gave the small amount of flexion or extension at the time of the original or first experiment was sometimes found to give a greater amount of flexion or of extension in a second test.

A phenomenon or reversal of another character was also found. When the stimulation of a center resulted in a continued or epileptiform contraction a second stimulation of the same center might cause an inhibition of this movement. In the same series of experiments it was found that "in one case the same point which yielded primary extension with much regularity, on re-examination twenty-eight hours later in the same animal, yielded at first primary flexion instead of the primary extension" (page 252).

Closely allied to the results of the present work is the fact, which Brown and Sherrington note, that "in some experiments, the area whence extension points could be chosen has been distinctly larger than in others" (page 252). These authors conclude that "this variability signifies less a difference in the permanent arrangement than a difference in the condition of the nervous system from time to time," but this conclusion does not appear to be in line with the facts which have been recorded here, nor does it appear to me adequate to explain all of the facts which these authors have recorded.

Most of the recent work on the recovery of voluntary control following various forms of nerve anastomosis also shows that there is not the degree of definiteness of control from a particular portion of the cerebral cortex which has been assumed. Were a

particular cell endowed with the particular function of sending impulses[8] to bring about only one special movement of the arm, it could never be used to bring above a movement of the face. Were the activities of such a cell associated with or, as some clinicians hold, due to "memory images" of shoulder movements, for example, there would probably never be the possibility of moving the face except by thinking of it as the shoulder. In man, as far as our knowledge goes, the acquired ability to move the face when there has been an anastomosis between the peripheral portion of the facial nerve and the central end of the accessory nerve is not associated with any "memory images" or thinking about the shoulder. This conclusion is also forced upon us because of the recovery of the facial mimetic movements, which are reflex in character.

The experimental work on animals gives us many facts of value in this connection. Kennedy (**8**), it will be remembered, crossed the nerves for the flexor and the extensor movements of the dog's leg and noted that after a time the animal was able to move the leg quite properly. He also found that when the motor areas of the cerebrum were stimulated, the stimulation of the portion of the cortex which is considered to be a flexion "center" was accompanied by an extension, and vice versa, indicating that new brain conections had been formed because of the peripheral anastomosis. The observation that the animal recovered to a very great extent the normal power of the use of the leg in locomotion demonstrates that there has been a rearrangement in anatomical distribution of the individual neurones. The results of the cerebral stimulation experiments on the brain of this dog are, however, not conclusive evidences of the rearrangement of function in the neighboring cerebral areas because the flexor and the extensor centers are anatomically very intimately related. The recent work of Brown and Sherrington, which has already been described, has well demonstrated that there may be a reversal of function of these areas, and it is theoretically, and practically, possible that the re-

[8] The use of the term impulse in this connection is convenient, although it is recognized that some physiologists object seriously to its use, because it appears to imply something more than physico-chemical changes.

sults of the cerebral stimulation experiments of Kennedy were due to the normal physiological relationships of the flexion and the extension centers.

When, however, we deal with the altered innervations of parts which are not as closely associated physiologically the same probabilities do not exist. The further experiments of Kennedy (**7**) are, therefore, less open to question, for he found it was possible to obtain the return of function in the appropriate parts when he connected the central portion of the cut spinal accessory or the central portion of the cut hypoglossal with the distal portion of the cut facial nerve. After these operations it was found that the first movements in the area innervated normally by the facial nerve came in 58 and 32 days respectively, and in about 100 days there was found to be a recovery of the voluntary control of the closure of the eye and of other parts.

Other motor areas of the cerebral cortex which are spatially less closely allied are also found to have the ability to assume functions not originally pertaining to them. Thus Osborne (**9**) and Kilvington, in their very suggestive research, found that if one brachial plexus was served and some strands were carried over from the opposite plexus and united with the distal parts of the one which had been severed regeneration of the nerve took place. This nerve regeneration was accompanied by a complete, or almost complete, return of function in both forelimbs. It was furthermore determined that if the cerebral cortex in the forelimb area was stimulated on the side contralateral to the completely cut nerve (which normally innervates the limb supplied by the nerves of the brachial plexus which had been cut), no reaction resulted, but if the cortex of the homolateral hemisphere was stimulated, movements of both forelimbs were produced. This is a clear and convincing demonstration of the fact that the function of a particular area depends more upon the connections that are made than upon any hypothetical inherent or innate function, and further, that the functions of a particular area may materially change in accordance with the paths which are formed. The recovery of normal function also indicates that the impulses received from the receptive areas of the cerebrum, which are considered to be

necessary for the proper performance of voluntary movements, are not singularly direct. Such impulses, following the assumption of their necessity and importance, must in an intact animal go in certain directions and in the operated animal in other directions by other paths.

The experimental work of Boeke (**1**) is also of suggestive importance, showing as it does that there is a possibility of regeneration even in those cases in which the cross-sutured nerves differ by as much as they do in the case of the sensory and the motor nerves. In some cases Boeke found that if the central end of the cut hypoglossal nerve was joined to the distal portion of the sectioned lingual nerve regeneration of the fibers took place. He has also been able to demonstrate that under these conditions some of the efferent fibers of the hypoglossal actually progressed to the surface of the tongue and made connections with taste buds.[9] It is not definitely proven that these connections resulted in a return of the ability to taste for those areas of the tongue which had been deprived of his function by the section of the lingual nerve. More experiments and more crucial tests respecting this matter are necessary before we may say there has been a complete demonstration of the functional regeneration. The fact remains, however, that the possibility of anastomosis between a sensory and a motor nerve has been demonstrated. What variations in sensory or motor activity have been the result of these tests will doubtless later be determined. That the normally efferent fibers may regenerate and pass to the sensory end organs as well as to muscle cells is a fact weighted with suggestions regarding many practical, but especially theoretical, problems.

Variations in the motor responses to cerebral stimuli have also been recorded by the Vogts (**11**), not only in different animals of the same species but also in different species of animals. It seems to me probable that many of the discussions of the physiologists and of the clinicians of the past in which there

[9] At the present stage work of this nature has more definite interest in connection with the peripheral distribution of the nerve fibers. It can readily be understood, however, that the possible central (*i.e.*, cerebral) relations are most important. Confirmations of Boeke's work are urgently needed, especially in relation to the variations in behavior of the operated animals.

were charges and counter-charges of ignorance, or of misstatement, or of technical defects were due to the fact that these variations were not known or were not recognized. I believe that if this fact had been known and understood many acrimonious discussions would have been prevented.

The Vogts hold to the view that the variations are due "in part to special development of other pallium fields, and in part to variaitons in the functional capacity of performance." They furthermore assert that nothing prevents the "connecting causally all variations in the number of foci and in the extension and to a certain degree also variations in the excitability of a certain field of stimulation with differences in the specialization of its motor functions."

On the other hand Sherrington (**10**) has written: "Every increase in the number of links composing the nerve cell chain seems to increase greatly the uncertainty of its reaction in artificial excitation. . . . A cortex cerebri might well therefore have been expected to yield under artificial excitation only extraordinarily inconstant results. To Hitzig and Fritsch, and to Ferrier, we owe the pregnant demonstration that as regards the motor region this expectation is not well founded." That this constancy is not a veritable one is, I think, fully shown by the researches of the Vogts as well as by the results of the present study. There is not the degree of constancy in the motor response which the earlier investigators, as for example those which are cited by Sherrington, contended there is. Moreover, the later results obtained by Sherrington in conjunction with Brown which have been discussed above must also be taken into account, for it appears to me they amply demonstrate the opposite of that which Sherrington wrote eight years ago, and prove that the stimulation of the same cerebral point at different times produces varieties of action.

Whether or not the variations in movement associated with cerebral stimulation are to be correlated with normal individual activities, an explanation which is only slightly advanced beyond that of the Vogts, is a question for the solution of which the closest observations and correlations of the normal activities and the extents and the variabilities of the motor cerebral control

of individual animals must be accumulated. At present such a view appears to be in harmony with all the facts which are known to me and is tentatively put forth pending further studies. It may also be remarked that this view, in a special form, has been suggested by Bolton (**2**) in relation to his anatomical studies of cases of "amentia" and of "dementia," for he writes that the anatomical variations indicate "the likelihood of a structural origin for individual differences in mental endowment,"[10] and on the other hand he says the histologically differentiated areas indicate the "limits of educability."

The results of the present research, in conjunction with the data of others which have been recorded above, indicate that the connections which are made by way of the cortical motor cells are not definite in the sense, for example, that there is a passage of an impulse from a Betz cell in the anatomically defined cerebral motor region to another particular efferent cell in the spinal cord, but that the connection is, in special senses of the terms, promiscuous or irregular. By these last terms I mean only that the connections which one particular efferent or afferant cell makes are connections with a great number of neurones, and that the impulses resulting from the activity of a cell body may affect many other cells. Or, in other terms, an impulse arising in one cell may activate or influence only one, or any number, of the cells which are anatomically associated with the particular cell with which we deal. It is quite generally admitted that a certain cell has the possibility of sending its impulses along the main neuraxon and this is the view which is implicitly apparent in most discussions of cerebral function. But it is also obvious that since this neuraxon gives off, as it passes to its final goal, certain collaterals it is quite as reasonable and quite as logical to conclude that it has also the possibility of sending impulses along any one of these, or along the main neuraxon and any number

[10] This is not quoted as an indication of sympathy with the methods and other conclusions of Bolton, who has, in fact, introduced forms of expression in regard to cerebral-mental relations which are obviously grossly inaccurate. Thus, to be specific, he says that by means of language "it is possible to perform the highly intricate processes of cerebral association," and that "if words spontaneously arise in a cerebral center," whatever these things mean.

of the collaterals, or along one or more of the collaterals to the exclusion of the main trunk. It is this later method of looking at the activities of the cerebral cells which appears to me to solve some of the great difficulties of the exclusive neuraxon activity hypothesis.

The illustration which is presented here (Figure 11) is one

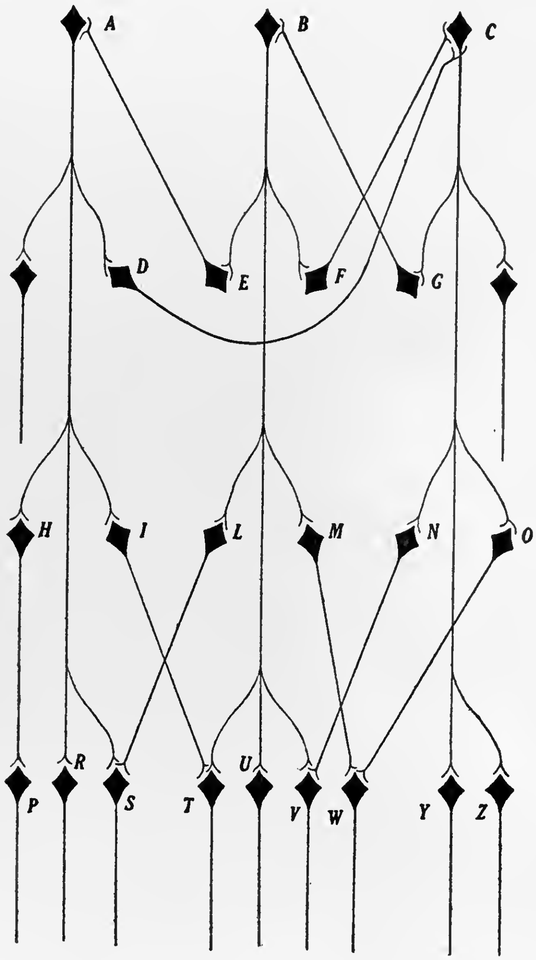

FIGURE 11. Illustrating the conception of the possibility of impulses in one cell influencing different cells, thus resulting in different reactions or different behavior. The primary cells *A, B,* and *C,* may be equally well considered to be afferent, efferent, or associational. Each cell may also be considered as a simplification of a group of cells.

which gives a diagrammatic conception of this view.[11] The activity of the cell *B* in its discharge may be represented as passing in any one or more of the directions taken by the branches of its neuraxon. Thus the activity of this cell may result in the stimulation of the cell *U,* or the cell *T,* or the cell *V.* In turn the activities of these cells (*T, U, V*) may result in the stimulation of muscles. On the other hand the activity of cell *A* may through its collateral acting upon cell *I* result in an activity of cell *T,* and the activity of cell *C* acting through its collateral on cell *N* may also bring about activity in cell *V.* Or, cell *C* acting through its collateral on cell *G* may activate cell *B* so that the characteristic *B* activities may be obtained. In turn the activity of cell B may influence those of cells *A* and *C* almost directly, thus bringing about reactions in parts which are normally controlled by those cells, for example those parts connected with cells *P* and *R,* and those with cells *Y* and *Z.* When it is considered that cell *B* may be taken as a representative of a so-called sensory cell, or an efferent cell which is normally made active when it received the effect of an impulse from some other cell or cells in other portions of the cerebrum, for example from a sensory or associational center, and that there may be many of these which exert an influence upon it, it will be realized that the behavior resulting from the activity of a primary receptive cell may greatly vary from time to time.

This neurological conception may be applied to the understanding of the behavior differences of individuals and also of the same individual from time to time. It appears probable that the variations in behavior of different animals and of the same animal at different times to the same form of stimulation are dependent upon the great number of connections and upon the variations in activity which the connection variations make possible. On the hypothesis that the connection between cortical cells is definite, in the sense that one cell acts solely or

[11] A few words of caution may be said regarding the diagram and its accompanying paragraph of text. Neither should be taken too literally, neither should be considered to be more than an indication of a possibility, and neither should be judged without the preceding and the following context.

principally upon one other cell, we shall have great difficulty in explaining the phenomena in man or in animals which are grouped under the general heading of habit formation. To show this, let us briefly consider the facts regarding the formation of habit in several animals. We shall then realize how the same stimulus may result in different reactions in different animals, and how in one animal at different times different reactions may result from the same stimulus. Conversely also we shall get some neurological insight into the possible reason for similar reactions in different animals from different stimuli. On the assumption of definite connections and definite paths of discharge such facts are neurologically almost unexplainable.

Let us take for consideration a young cat, four to six months old, since an animal of this kind is readily "educable." If the animal is hungry it will be better, since the formation of the habit is then more readily obtained if the habit has one of its elements concerned with the obtaining of food. We prepare for our experiment a box with narrow slats in the front and a small door which is closed with a bolt. The knob of the bolt is attached to a cord which runs along, but an inch under, the top of the box and which the animal can reach either with its claws or by arching its back, or by biting with its teeth. When the cord is pulled downwards or pushed upwards or moved sideways the bolt is also moved. Any one of these actions (there may be others and also combinations of two or more of these actions) will, if sufficiently strong, result in the loosening of the bolt which keeps the door closed, and when the door is thus opened the cat is enabled to escape and to get a particle of food which is placed outside.

When we place a cat in an enclosed space of this character there is a very decided change in the behavior of the animal. It usually becomes very active. This activity we may describe, in terms which are not directly scientific in their psychological aspect, as being due to the desire on the cat's part to escape from the uncomfortable situation of being in an enclosed place of such small compass, and perhaps partly to the desire for the food which in some experiments it may see outside. The actions

of the particular cat under these conditions are about the same as those of other animals of the same species which are placed in such a situation. The animal begins to scratch at the front of the cage, at the door, at the sides, at the top. It turns here and there, it takes hold of everything or anything which it can reach. These movements are not performed in any apparently logical order or in any apparently intelligent manner since the animal may at first try one corner, then the top, perhaps next the door. If these movements do not result in the escape of the animal from the "unpleasant" situation the cat may remain quiet for a time and begin all over again scratching at a front corner or a back corner, trying the top, the door, the slats at the front. Even though the special movements do not result in the release which is sought the movements are continued, and if the cat tries one thing and does not escape by so doing it may return to the first which it had previously found unsuccessful. The random movements, if they are continued for a sufficiently length of time, eventually result in the animal's moving, either by clawing or by arching its back or by biting, the cord which holds the bolt. When the bolt has thus been lifted the activities of the animal may be continued for some seconds or minutes before it realizes or recognizes that the door is open and there is a possibility of escape. When the animal escapes from the situation it finds the food or it is given a small piece of food. When it is returned to the box which is again bolted it goes through the same kinds of activities, clawing here, biting there, resting, performing movements which are apparently purposeless since they are not directed to the part of the box by which escape becomes possible, or towards the mechanism whereby the door can be opened. In its random movements it again scratches the cord, and again escapes and gets food. At the next trial the animal goes through the same sort of movements. Finally it claws the cord, gets out, and in succeeding tests it is found that this animal which at first escaped because of biting the cord and then later by arching its back against it, and again by clawing at the cord eventually acquires the habit of escape by utilizing only one of these types of move-

ment, namely the scratching or clawing at the cord. Furthermore it is found that when an animal is placed in this situation it eventually acquires the habit to such a degree, or the reaction is facilitated to such an extent, that immediately the animal is dropped into the box it goes to the particular location, claws at the cord thus opening the door, escapes and obtains the food.

Another animal goes through the same general kinds of activities in its escape or its attempts at escape, but instead of acquiring the habit of escaping by means of clawing at or by pulling the cord, it acquires the habit of arching its back and rubbing against the cord, thus putting the cord on a stretch and raising the bolt. A third animal learns to escape from the box by biting and pulling upon the cord.

It will be observed that as far as we can determine all three animals have been stimulated by exactly the same primary forms of stimuli. They have been stimulated by the sight of the box, by the appearance of the slats in the front, by the closed door, by other ill-defined sensations which are obtained from the confinement, perhaps from the stimulation of a variety of organs which go to make up, in human perceptual terms, the general feeling of being enclosed in the box. The sensory elements which are present in these three cases we most likely have the right to conclude are the same. The emotional elements or concomitants we do not know, if any exist, and we have at present no means of determining the similarity or variety of these mental conditions if they exist. It is to be noted however that although the sensory stimuli are the same the behavior to which the stimuli lead differs in the three animals. The reactions, it will be observed, have one thing in common, namely that they result in the escape of the animal. The actual means, however, of producing this desired situation differs for the three animals. Neurologically it is not only likely but it is almost certain that the impulses from the sense areas, those so-called associational impulses which start from the cells in the sensory regions of the brain, eventually concentrate in these three animals in different motor areas, or to put the matter in more probable terms, that the impulses originating in similar sensory cells in all three

animals reach (*a*) the same or (*b*) a different frontal lobe cell or group of cells in all animals, and that (a) this similar frontal cell or group of cells discharges into different cells in the precentral area, or that (b) the different frontal cells influence motor cells.

Now it will furthermore be found that if an animal which has acquired the habit of escape from a box of this character, either by clawing or biting or rubbing against the cord, be placed in the same box and the movement which it has been accustomed to make results in no food or in no release, this movement is gradually given up. The situation becomes different, although the sensory stimuli remain the same. By holding the bolt or by making some external change in the mechanism (which is not seen by the animal) to prevent the escape by any movement of the cord, but to permit the escape whenever the animal sits quietly and licks itself, or washes its face by the characteristic series of paw movements, or scratches itself, the animal soon gives up the first habit which it had formed and replaces it by behavior which in itself has not apparently any direct bearing upon the desired result. We then have a similar primary series of stimuli which at one time results in a particular mode of activity (clawing the cord), and at another time in a different mode of activity (licking itself) in the same animal. Both lead to what may be considered the desired result, namely the escape from the enclosed box.

It should be understood that the sensory stimuli in two experiments of this character are not the same in their totality. The initial or primary sensory stimuli are, however, the same. When after the receipt of the primary sensory stimulation a reaction is produced the reaction results in an additional sensory stimulation, and this secondary stimulation, or the combination of the secondary with the primary, may give rise to another reaction. The animal which claws first at the front of the cage after the receipt of the primary stimulation has thereby a character or combination of stimulation different from that of the animal which first reaches for the top of the cage and tries

to climb out in that way. Each animal however does have the same primary stimulation, or at least the same general primary stimulation, visual, tactile, organic, etc. To go back to the original stimulation we may even wonder why such similar primary stimuli have produced such diverse methods of behavior as that of clawing at the slats at the front of the cage and that of trying to bite the slats at the top. In either case, whether we consider the primary stimulus or the collection of stimulations which make up the whole experience of the animal in the box the sensory stimulations are sufficiently alike to presuppose (on the basis of exactness of neurological connections) an approximate similarity in the activity of the cerebral sensory areas, and to suggest (on the same hypothesis) that the efferent cerebral activity should be the same. This is, of course, on the very generally accepted belief that the impulses from corresponding sensory cells will always go to corresponding efferent cells.

On the hypothesis that there are definite connections established by means of certain cerebral neurones, and the hypothesis that when the stimulation reaches a particular sensory center it flows into other areas, eventually reaching the motor area and resulting in a particular type of movement, the varying activities of these animals are not understandable. It is not an explanation to say that one animal has certain sensory stimuli like those of another, but that there are different activities. Neurologically, there must be a basis for the different kinds of behavior. When we consider the possibility that the discharge from a certain cell may pass not only along the main neuraxon but also along any one or all of the collaterals and that in this manner we have the neural activity diffused, we have a possible explanation of the variety of the actions of the same animal under similar conditions. If the receiving cell were definitely and solely (anatomically and physiologically) connected with a special cell or group of cells, the same sensory stimulus should result in the same kind of reaction in different animals and in the same animal at different times. But we find that at first the cat makes many random movements. In other words, neu-

rologically we are led to conceive that the discharge of the sensory or receptive element is not only along the main neuraxon but is along all of the collaterals as well, and each in turn acts upon its cells or group of cells, producing impulses which eventually result in movements. These movements are random, i.e., not directly correlated with the stimuli nor with the desired result, but as the experience is repeated the animal gives up all but a certain amount of the reaction. Its behavior has changed. It is not only believable but probable that in the development of a particular type of activity or in the production of a particular association or habit, such as that of scratching or of biting or of arching the back, we may have two different neurological conditions. To use the simplified diagram which has been given above we may say that at first the discharge takes place along all the branches of the neuraxon, but this diffuse discharge eventually gives place to a discharge along one of the collaterals or along the main branch. The variation in behavior of two animals may then be due to the primary stimulation of corresponding cells, but in one case the habitual reaction is determined by the flow of the impulses from these cells along the course of the main neuraxon and in the other case the habitual reaction is determined by the passage of the impulse along a collateral These impulses reaching different efferent elements produce the varieties of behavior.

The results of the preceding study (**5**) of the variation in symptoms accompanying similar cerebral lesions in the insane have also a bearing upon the present work. In that study it is shown that in four collections of cases of patients suffering from different mental diseases, in whose brains atrophies of the frontal or anterior regions of the cerebrum were detected at autopsy, there is no apparent relation between the symptoms and the localization or the degree of the cerebral damage. On the assumption that there are definite, in the sense of singular and similar, functions and functional connections in each hemisphere in all individuals such divergencies in the symptomatology are not readily understandable.

At the same time the accounts of my experiments on the

functions of the frontal lobes (**4**) contain material of importance for the understanding of the cerebral functional relations. In that work it was shown that after an animal had been trained to react in a certain way, or had acquired a certain habit, the habit was lost when parts of the frontal lobes were separated from the remainder of the brain or when they were destroyed. Even after the loss of a great amount of the frontal regions such an animal could, however, reacquire the lost habit. The reacquired habit could again be destroyed (or lost) if additional portions of the frontal lobes were extirpated, and in some animals it was possible to show that the same habit could be again acquired.

It is neither satisfying nor sufficient to say that in the latter experiments there has been an inhibition, for this can only give to the facts another name. Nor does it suffice to say that there has occurred a sort of "diaschisis," since this also is only another means of expression of the generalized fact of loss of function. What must be concluded from these facts is that at the time of the first extirpation there was a "diaschisis," or blocking, or break, in the normal chain of cerebral activity (or neurologically and anatomically, of the cerebral connections). After the second learning of a habit and its loss subsequent to a second and more extensive extirpation, "diaschisis" may again be taken as the explanation of the fact. Another explanation beyond those of "diaschisis" or inhibition is demanded, however, for the phenomena of learning after the first extirpation of the cerebral area through or by which learning or habit formation normally is possible. It is obvious that the normal (*i.e.*, the first) paths cannot be traversed again, for these have been interrupted, or perhaps abolished. It is obvious that new paths or new possibilities of connections must be available. In other words for a reasonable explanation we are thrown back upon the assumption that the paths for reactions are not the simple anatomical unities which have been commonly believed in but that these paths are diverse and that anatomically as well as physiologically they are complex.

If the neurological path for the formation of a habit is a

fixity—from a certain sensory center to the frontal lobes and thence to the motor cortex—a break at any portion of the path (diaschisis, if you will) would prevent for all time the reacquirement of the lost association. That there is no such fixity is evident from the fact that relearning is possible. The explanation of the fact must, I think, be sought in another direction, and the one which has been suggested above appears most reasonable. It appears probable that in the acquirement of a habit certain paths are traversed and that they have a certain fixity, but it is also probably true that these paths are not the only ones that may be used to bring about the desired connection or association between the sensory and motor end stations. Most probably other subsidiary paths, if it be considered necessary or advisable to differentiate between the first path and other paths, or relatively subsidiary tracts, are available when "diaschisis," or inhibition, or other similar conditions supervene to prevent the normal course of the cerebral impulses.

The conditions of variability and the conditions of variation in the particular responses which come from rather definite sensory stimulation in different individuals lead us to a better understanding of the neurological conditions which we must believe are present in individual cases. It is not sufficient to say, as is commonly said, that past experiences determine reactions, for this is only a consideration of the matter from the external viewpoint. It gives no conception of the neurological conditions which enter into the matter. At present I think it will be admitted that we are quite ignorant of the conditions which result in the selection (not necessarily conscious of course) of a definite path in the nervous system. It is undoubtedly true that certain paths are fixed in the sense that one neurone has fairly direct connections, synaptic, however, with other neurones and also that one neurone may have connections with a half-dozen or more other neurones. Why the stimulation of one neurone should usually give rise in one individual to a particular reaction and the stimulation of what we believe to be a corresponding neurone in another individual results in a reaction which differs somewhat from the first, we

are not aware. It is, however, of some consequence and of some importance to realize that there are greater possibilities of connections than have hitherto been assumed or believed in.

Only on the ground of the assumption of variations or possibility of variations in the connections or in the patency of collateral and main tracts may we understand the behavior phenomena to which the same stimuli give rise in different individuals. Only on this basis can we understand the various activities of different races and of different individuals. The different races have, it is well known, different types of reaction. Anatomically we have no good reason to believe that the neuronic connections differ widely in different races, nor anatomically have we any good reason to believe that the neuronic connections in different individuals of the same race or of the same family differ very widely. It is apparent, however, that physiologically these connections are very greatly different for the activity of the neurones gives rise to behavior of quite different characters.

Thus far we have been considering what is doubtless the most simple neurological system, a system much simpler by far than that which is active in the production of any form of behavior higher than that of a reflex. When we deal with a system containing more than the two elements, afferent and efferent, or receptor and effector, the complexities of connections and the possibilities of variation in the physiological connections become apparent.

In this respect the cerebral cortex, or the cerebrum as a whole, may be looked at as a very labile organ because of the numerous possibilities of connections which may be made. One cell, let us say, may have close connections with a half-dozen or a dozen other cells, and the activity of the primary cell need not always be through all the branches. There is a possibility of a change in the direction of the impulse within the neurone. Thus at one time the main effect may be due to the influence exerted through a certain collateral, and at another time the effect may be due to the impulse passing through the main axon or through a second collateral. If this be true, it helps

to understand why there is a possibility of change in reaction and a variability of reaction in the same individual from time to time. At one time the individual may have a discharge from a cortical motor cell along the main neuraxon acting upon a definite cell located in a definite region of the spinal cord. At another time the discharge may take place not only along the main neuraxon, but along one or more of the collateral branches, the actions resulting from the impulses passing through the collaterals being added to that due to the impulse along the main fiber, and the actions along these collaterals producing effects on other cells which either inhibit or alter in character the actions which were formerly produced, or new reactions may entirely replace the original activity by an activity of a very different character.

Nor does it appear necessary to believe that once a path, by way of the main trunk or by one of the collaterals, has been fixed that this fixity is a permanency. There may be a greater tendency to use this particular path after it has been used a number of times, but it may be said with certainty that the impulse may under suitable conditions traverse any one or all of the other collateral paths. In a state of "mental panic" a man acts very differently to a particular stimulus than at other times. His actions may be more diffuse or they may be the opposite of those which he habitually performs at normal times. Thus, the sounds of a rifle-shot heard at two different times although both be of equal intensity may give rise to varying reactions. Especially when there is an affective condition, such as fear or apprehension, do we find such changes taking place in the reaction.[12] Neurologically, however, it is not satisfying to say that the emotional condition gives the "set" to the discharge of a particular cell, or that it directs the character of the discharge, for we know nothing of the neurological conditions which give rise to or accompany affective states. But,

[12] Particularly those of diffusion. Neurologically perhaps we may consider such diffusion to be due to the passage of impulses from a cell not only along the path commonly traversed, but along all the collateral paths as well.

should we admit that the emotional state can alter the character of the motor response due to such a simple stimulus as that of the sound of a rifle-shot, we are admitting at the same time that the impulse from a sensory cell, or group of cells, may pass through certain paths at one time and through other paths at other times. Such a condition may also be well illustrated by a difference in behavior when no affective state intervenes to alter the reaction or when the affective state remains the same with the presentation of the stimulus at different times. An illustration of this is that of the differences of speech, which are special reactions or forms of behavior, when the same picture of an object is shown at different times. At one time such a stimulus (the picture of an apple) may bring forth the reaction *"Apple,"* at another time *"Apfel,"* and at a third time *"Pomme."*

It seems most likely that these variations in activity are due to physiological variations in the traversing of the axon or the collaterals. It is not unlikely that as conductors the axon and the collaterals are physiologically equal, that they may be utilized equally well or equally often if occasion demands it, and that the definiteness of response to any particular stimulus is only a relative definiteness.

In considering the functions of the cerebrum, therefore, we must rid ourselves of any preconceived notions regarding the fixity or definiteness of connections. Fixity or definiteness of an anatomical nature there undoubtedly is, but this fixity or definiteness is on the physiological side a multiplicity of fixities and definitenesses. One cell undoubtedly communicates with many others, and while this is an anatomical fixity it does not result in a physiological definiteness since at one time such a cell may be conceived to discharge in one direction along one collateral and at another time in another direction along another collateral. At present we may not have sufficient information to guide us in determining the reasons for the discharge in this or that direction but the facts at hand indicate that discharges do take place in this manner.

Somewhat similarly we must explain the facts of differences

in symptoms which are associated with similar cerebral lesions which have been referred to in a preceding paragraph. If we conclude that the cerebral paths for habits (or in a gross phrenological sense, for mental operations) need not be the same for all individuals such symptomatological dissimilarities in connection with like lesions become clearly understandable. If all individuals do not use the same limited portions for the same activities (or again in a phrenological vein, for the same mental processes) the destruction of similar portions of the cerebrum in different individuals need not produce the same symptoms. There are at hand sufficient facts in clinical neurological literature to support the contention that similar lesions do not always produce similar clinical symptoms or do not result in similar mental alterations. There are also at hand sufficient facts to warrant the conclusion that dissimilar lesions may produce similar symptoms. From the extreme viewpoint of body-mind relations (to which, however, I do not adhere) such facts are sufficient to lead to the conclusion that the same mental operations are not always due to the activities of the same parts of the brain. From a more conservative standpoint the facts warrant the conclusion that the same forms of behavior are not always due to the activities of the same cerebral cells. That the variability in the functional cerebral connections should ever have been considered doubtful is probably due to the phrenological views which have influenced, and in fact pervaded, all neurological literature for many years.

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The Psycho-physiological Effect of the Elements of Speech in Relation to Poetry

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THE PSYCHO-PHYSIOLOGICAL EFFECT OF THE ELEMENTS OF SPEECH IN RELATION TO POETRY

The purpose of this investigation is to determine by means of the expressive method the effects produced by the speech elements in poetry upon both the motor and introspective consciousness.

Lying on the borderland between Esthetics and Psychology, the investigation aims to throw light (1) upon the so-called "tonal theory of poetry," by measuring the emotional value of the sounds in poetic language without reference to alliterative or grammatical devices, and (2) to discover what auditory, kinaesthetic and organic sensations are aroused by the play of vocal functions in meaningful as well as meaningless collocations of the elements of language.

The material is presented in the following order:

1. A statistical determination of the frequency of the various speech elements in English poetry,

2. Experiments upon the psycho-physiological effect of such elements combined in simple relations,

3. Transmogrifications of English poetry to determine reaction to the bare tonal elements, and

4. The esthetic and psycho-physiological question: Is the psycho-physiological value of the poetic sum equal to the sum of the psycho-physiological values of the separately contributing phonetic elements?

1. SOUND FREQUENCY IN ENGLISH POETRY

Prior to undertaking the experimental work in the laboratory, an elaborate statistical record was made by the writer of the percentage of frequency of the various letter sounds in the leading English poets from Sydney to Rossetti. The basis for this work was the observation of very striking differences in the acoustic and kinaesthetic sensations aroused by the audible

reading of different poets. Especially was the motor pattern and the tonal display of such poets as Byron and Keats noticed, and upon analysis it was found that sound frequency was one element likely to contribute to the differences between the effects which they produced. A previous study of vocal music to provide an increased sensitivity to tonal effects, and of phonography to hasten the sensori-motor reactions necessary in making the tabulations were found to have been invaluable psychological instruments in this preliminary work. This analysis required over four years and involved the recording of over 540,000 tonal elements; 46 phonetic rubrics were employed, and where doubt was entertained over the classification of the elements under the various rubrics, recourse was had to general poetic usage as well as to the special idiosyncracies of the individual poets. All the poets were analysed upon the basis of the current English speech, the Standard Dictionary being used as the criterion for pronunciation. The "foot- and -quantity" system was employed to determine the accentuation, and both accented and unaccented sounds were registered in the tabulations. Approximately 1,000 lines of the maturest and most melodious verse of each of the poets were examined. The result of this work is here summarized:

I. English poets usually employ about 10 accented to 8 unaccented sounds. Shelley, Browning and Swinburne are the notable exceptions, each of which gives the ratio of nearly 10 to 10. But their rhythmic patterns determine much of this.

II. Greater variations, general and individual, are noticed in the use of the accented than of the unaccented sounds.

III. Tennyson and Swinburne deviate most from the average use of the sounds; Milton is nearest the average of all the poets examined.

IV. The greatest individual variations are found among the most used accented consonants which occur in the following descending order of frequency: R, N, L, T, S, D, M, etc. But the smallest individual variations in the use of the unaccented sounds occur among those of the greatest frequency of use, namely: ŭ, ĭ, ă.

Only a few double consonantal rubrics were employed besides

the familiar Ch, Wh (Hw), Ng, Sh, and Zh; such double sounds as Bl, Cr, etc., were split and tabulated as two sounds. While the work was in progress Josselyn's investigations (see Scripture, "Elements of Experimental Phonetics," p. 501) came to hand, in which it was shown that a double consonant was simply a single one strengthened and lengthened, in so far as the time estimation of rhythmic syllables was concerned; but whether the double or triple consonantal combinations were felt as fusions or as additions did not enter in as a standardizing agent in the above work of tabulation.

Perhaps the most striking thing in the whole work was the constant observation of the modifying influence of R. Besides being the most used sound in English poetry, it is the one most frequently observed as modifying the quality of juxtaposed vowels and consonants, and when so found, its local signature is absorbed by them.

2. THE PSYCHO-PHYSIOLOGICAL EFFECT OF SIMPLE SOUNDS

The experimental work was carried on in the Psychological Laboratory of Harvard University from 1911 to 1914. It began with the audible recitation of groups of five iambics, such as la-mo, la-bo, and la-do. The O was long, and the A was given as the 'Italian' A. On account of the neglect it received in the arsus, however, it became the neutral vowel. The time of the recitation was taken and the chief results were: the appearance of a caesura, the feeling of satisfyingness at the fifth iambic, the changes in feeling-tone, sensations and imagery, as the different combinations were presented. Only the above three iambics were employed this way; in order to obtain a record that was valuable for the correlation of so motor a function as speech, some graphic record had to be employed.

Historical

Brücke[1] had obtained kymograph records of ictus and arsis by means of a quill marker while various kinds of verse were

[1] Brücke, "Die physiologischen Grundlägen der neuhochdeutschen Kunst."

recited.[2] Lip movements were also recorded by means of a lever passing from the lips to the kymograph. His findings were that the time taken to tap various kinds of poetic feet were almost equal; at least the arses recurred at equal periods of time, and the abruptness of the departure of the kymographic tracings from the abcissa line was found to vary considerably for different poetic metres.

Bourdon[3] had traced the neck vibrations at a particularly mobile place, while certain sounds were uttered, and found very great amplitudes for the vowel I, less great for O, and lesser still for A. It appears, however, that the average amplitudes for combinations of consonants with O was greater than those with I and A; the I-combinations being quite the lowest.

In regard to what one might expect with reference to the general permeability of the psycho-motor organism to stirs of various sorts, Angell[4] held that "only those sensations breaking in upon a state of relative quiet disturbed the psycho-physical mechanism enough to make any peripheral difference."

Fere's opinion[5] on this matter is that a momentary intellectual activity is accompanied by a momentary increase in power of the voluntary muscles. He also found that both under the influence of an intellectual effort and of other things (*e.g* , speech and odors) certain excitations of the muscular sense were aroused. His studies showed that during the exercise of speech the movements of the right hand were influenced, *i.e.,* augmented, just as one works a treadle with the foot and finds the synchronous hand movements augmented as much as a 6th or a 5th; it is even stated that the right hand in gesture plays a veritable "esthesiogenic" rôle. But the correlation of the amount of energy expended with pleasurable or unpleasurable states, Fere does not report in the case of speech; in connection with odors and the

[2] The study was not of the pure iambic or other line; inversions of feet occurred, as usual.

[3] Bourdon, P., "L'application de la methode graphique a l'etude de l'intensitie de la voix," *L'Anee Psychologique,* 1897.

[4] Angell, J. R., "Organic processes and consciousness," *Psych. Rev.,* 1890.

[5] Fere, Ch., "Sensation et Mouvement," 1900, esp. Chap. 3.

like, the greater energy seems to be aroused in a state of pleasure. But the final generalization is in these terms: "La sensation de plaisir se resont donc dans une sensation de puissance; la sensation de deplaisir dans une sensation d'impuissance."

The development of the expressive method itself is a fitting corollary to the "modern tendency to understand all consciousness in motor terms," and to connect it with the "motor rather than the sensory side of the organism."[6] Professor Münsterberg's action theory allies itself with the same tendency. Such writers as Dearborn,[7] Pillsbury,[8] Alexander,[9] and others give a large place to the psycho-motor side of the neural arc, though treating the consciously volitional side of consciousness with varying degrees of prominence.

In their experiments upon the "Time relations of poetic metres,"[10] Hurst and Mackay appear to have justified somewhat the method of poetic analysis used herein (only indirectly, however), and while their subjects only scanned silently or tapped empty rhythms, they found that the iambic foot was really short-long and thus that the tapping of the metrical unit laid a stress upon the so-called accented syllable. Inasmuch as greater differences appear among the poets (as found by the tables previously mentioned) in the use of accented than of unaccented sounds, the above results are pertinent to the present investigation. Further comparisons of method and results are hardly possible; they used the iambic foot only in octosyllabic lines, (*e.g.,* Scott's poems), and even then the iambus was frequently exchanged for other kinds of feet.

Scripture's subjects[11] read rather than scanned poetry. Triplet and Sandford[12] found that the explosive consonants were

[6] Kostyleff, quoted from E. B. Delabarre, "Volition and motor consciousness-theory," *Psych. Bull.,* 1912.

[7] Dearborn, G. V. N., "The relation of muscular activity to the mental process," *Am. Ed. Rev.,* 1909 (14) 18.

[8] "The place of movement in consciousness," *Psych. Rev.,* 1911, (18) 83-99.

[9] *Brit. Jour. of Psych.,* 1911 (4) pp. 239-67.

[10] Univ. of Toronto Studies, No. 3, 1899.

[11] Scripture, E. W., *Yale Psych. Stud.,* Vol. VII, 1899.

[12] "Studies of rhythm and meter," *Am. Jour. of Psych.,* XII, 1901.

more nearly tapped and spoken at identical times than were the others. S was almost always syncoped. But in the general, they found that finger stress indicates quite well the vocal stress, though minuter correlations are not indicated. To the above results we ally those of Meumann[13] which state that the time limit of syncope is but 0.02 seconds. Miyake[14] found that the beat of the finger came before the beginning of the vowel when it stood alone, when it had a glottal catch, when it was short or long, followed by a final consonant, or when it was short or long between two consonants. Also, except in the case of B, D, and G, the beat as tapped came before the vowel following these consonants.

With regard to the matter of correlating qualitative consciousness states with the motor consciousness, there is to be mentioned Dressler's work[15] where increased central activity seemed to favor increased rapidity in voluntary movements; also the work of Drozynski[16] which does not crystallize into any specific positive correlation, but shows apparently that the unpleasant stimuli gave the more noticeable arousals. But by 'unpleasant' we must understand here the many meanings of the term in the sense of Wundt's tridimensional theory. This writer used no iambics.[17]

So much for a general account of some of the more important and resultful experimentations upon the motor and introspective phases of an expressive method in psychological esthetics (especially *in re.* poetry). But to come down to the particular elements of our own research, especially the form of the rhythmical presentation and the apparatus used; and first the rhythm form.

[13] "Untersuchungen zur Psych. und Aesth. der Rhythmus," *Wundt's Studien*, X, 1894, p. 419.

[14] See Scripture, "Elements of Experimental Phonetics," esp. Chap. 37.

[15] "Excitement and tapping rates," *Am. Jour. of Psych.*, 1891, IV, p. 523.

[16] "Atmungs und Pulssymptome rhythmischer Gefühle," *Wundt's Psych. Stud.*, Vol. 7, pp. 83-140.

[17] See also for the effects of pleasant and unpleasant music, F. Rehwoldt, "Ueber respiratorische Affectssymptome," *Wundt's Stud.*, Vol. 3, pp. 149-192.

The Choice of the Iambic Foot

It was shown above that iambus is a sufficiently characteristic form to be used as a vehicle for sounds (*op. cit.* Hurst and Mackay). There is another justification, however. From the writer's own experience in the field of literature, the standard, as well as the most dignified line of English poetry is the iambic, decasyllabic line; the comic finds a place much more readily in the octosyllabic (and trochaic) line, or in still smaller forms. No longer line than this has succeeded for great lengths of verse, and most of the sustained work of any considerable length (barring of course Coleridge's "Lyrical Ballads") is written in it, and even lighter works such as sonnets are not rendered over heavy by its use. The iambic foot was chosen because it appeared to be the standard foot in English poetry, not because exceedingly frequent inversions of it did not occur, nor because dactylic and anapestic innovations were not part of the very body of even the heavier epics, nor because runover lines did not frequently render the iambic-trochaic mêle of feet difficult of interpretation in favor of one or the other kinds as the predominant foot,—but because the stress of the accented syllable of the iambus seemed to bring more into prominence the sounds meant to be stressed than did that of the trochee. Hurst and Mackay (*op cit.*) found indeed that the iambus detained its ictus in the motor consciousness twice as long as its arsis, while the time relation of ictus and arsis in the trochee was only 3/2 to 1.

The experiments carried on by Stetson[18] and Bingham[19] had effectually shown the advisability of employing some simple voluntary process as a basis for psycho-motor correlation. The method herein employed is practically the same as theirs. The voluntary process used was the tapping movement of the right index finger. This movement is exceedingly simple and natural, and soon tends toward automatism, leaving one's attention entirely free to be directed upon the stimulus. Very rarely did the finger movement return to consciousness after it had become automatic; when it did so, introspection showed a very unpleasant

[18] "Rhythm and Rhyme," *Harvard Psych. Stud.*, Vol. I.
[19] "Studies in Melody," *Harvard Psych. Stud.*, Vol. II.

and turgid state of consciousness; which state seems to be present usually when any chain of habitual responses is broken.

The Apparatus

The form of the apparatus was as follows: Upon two tables placed about two metres apart, revolving brass drums were fastened; over these drums passed a smoked paper belt; the driving mechanism was at one end, the record-taking device was at the other. The subject sat comfortably at the side of the table and laid his right arm on a flat wooden rest having a notch sufficiently long to avoid all possible interference with the index finger, which was left free to move throughout its entire natural range of flexion or extension. To have had the finger strike against some resisting surface would have prevented our detecting any slight variations which the stimuli produced and inasmuch, also, as the characteristic departures of the tapped strokes from the abscissa line were of great importance for most of the subjects, the lack of objective controls in the tapping was an obvious advantage.

The periodic movement of the finger was recorded as follows: the end of the finger was placed in an oilcloth cot which was used for all the experimental work without being changed, and from the cot ran a fine silk thread up over a small brass pulley (always kept well oiled) through a guide, and was fastened to a small aluminum marker of triangular shape. From the other end of the marker ran a small rubber band to an unright support. The point of the marker rested on the smoked ribbon, at a place on its surface quite close to the vertical axis of the drum, and so neatly was this whole apparatus constructed and so slight was the tention of the rubber band, that it was hardly perceptible to the subjects and did not interfere with the freedom and naturalness of the movement. The tension was not altered throughout the experiments. The thread and rubber band were renewed in duplicate at about equal intervals and thus the mechanical errors in the recording device were reduced to a minimum.

The smoked paper ribbon was driven by a gravity motor of sufficiently constant speed to reduce the error of inconstancy to

less than 1 per cent. Its rate was 1 cm. = 1.54 sec. The driving mechanism was enclosed in a 1⅛ in. soft-pine box, lined with very heavy felt, and the only sound audible was an exceedingly faint, and not unpleasant whirr, which soon became accommodated and was never again noticed. A control string passed from the motor up over a pulley to the other end of the belt to where the experimenter sat, and thus the movements of the experimenter were very slight.

As the finger moved up and down while the ribbon revolved, tracings were made on the smoked surface and, since the pointer accurately recorded the full extent of finger movement as well as such qualitative differences as suddenness and quiverings in flexion and extension, the smoked paper ribbon translated much of the voluntary movement into visible terms.

No suggestions or illustrations were ever given as to rate or extent of finger movement; each subject was allowed to make his own pattern, and for this a little preliminary tapping was employed using empty 5-iambic lines. In recording the introspection, which was done without inserting a screen between subject and experimenter, great care was always taken to betray no sign that the introspection given was agreeable or not to the results sought after. At least, all conscious control of the matter was assiduously avoided.

The apparatus was arranged so that the subject sat facing the window, from which only a patch of sky was visible; the aspect was northerly, and there being little or no direct sunlight, the lighting of the room was fairly constant throughout the whole period of experimentation.

Preliminary Experiments

The first experiment to be tried with the above tapping device was a decasyllabic line made of five iambics, repeating la-mo. This line was repeated five times. The instructions ran as follows: "This is an experiment upon the psycho-motor effect of the sounds in poetry; while you recite the line, tap at each accented syllable; take your own time to do it, tap in a natural way, in as long or as short strokes as you please; say it in a clear voice

and then introspect upon the three factors of feeling-tone, sensations and imagery, if all three come; otherwise just give me the introspectional conscious content, much or little; it is the sounds and their effects which you are to attend to. I pull this string and start the motor; after that, whenever you are ready, recite and tap; the line is to be spoken and tapped five times; pause between the lines just enough to control the start of the next line; have you got the instructions in mind? are you ready? etc." This instruction was not repeated in toto at every hour's work to every subject; as much of it, however, as was deemed necessary from psychognostic reasons was repeated, in order to get the same 'set' for each group of experiments. Inasmuch as the motor field was so narrow, the tapping soon became automatic, and the instructions could be reduced to: "This is to be tapped as the others were,—on the accented syllable." And since most of the experiments were written out and the accents marked in red, this fact rendered full instructions obsolete.

La-mo was followed on the same day by two other experiments, la-bo and la-ro. All of the eight subjects found the la-ro pleasant; one subject, W., found la-mo unpleasant, and A. found la-bo unpleasant. In general, la-mo was found to have a "soft, smooth character," like the gentler sounds of nature; la-ro, on the other hand was said to represent the roar of waves and to have less personal reference than la-mo; while la-bo implied something insistent and was referred to as "trivial."

One cannot lay much importance upon the affect-motor correlations in these experiments, for the subjects had not yet become accustomed to the tapping; A. and W., for example, found it more convenient and natural (?) at first to represent the ictus by an up-stroke of the finger. The down stroke was suggested, and they attempted it, but for the first few weeks, at least, found that it was more difficult to employ it. The records, nevertheless, were measured with respect to the ictus, whether it had been functioned by an up or a down stroke. It seemed very curious that an accented syllable should be represented by means of the weaker of the two movements of the finger.

Of these three combinations, la-bo appears to have aroused the greatest feeling of energy. A. seemed to find it so; B. certainly declared it as such; L. and T. also indicated the same tendency. But B. moved his finger farther in the recitation of la-mo and la-ro than he did in the more "energetic" la-bo. So did L., while T. who found la-ro to represent "something substantial" employed the greatest force for that sound, and was consistent with respect to la-bo, which he called more active than la-mo. But this was all in the learning stage, and it is not surprising to find that practice increases the length of the tappings, on account of the greater familiarity and confidence with the work which it brings. The subjects were asked to rank these three experiments according to pleasantness, and the following scheme shows what relation degrees of pleasure have to motor discharge in this first group of experiments. (Descending pleasantness represented by A. B. C.)

Subject	(A Tapp.) Av.	(B. Tapp.) Av.	(C. Tapp.) Av.
A.	-ro 44.1 mm.	-mo 38.3 mm.	-bo 44.9 mm.
B.	-ro 78.1	-mo 83.5	-bo 76.2
F.	-ro 45.8	-mo 58.0	-bo 46.4
L.	-ro 51.8	-mo 66.7	-bo 50.7
N.	-ro 86.8	-bo 87.7	-mo 83.3
T.	-ro 76.0	-bo 73.6	-mo 62.6
W.	-ro 54.8	-mo 24.6	-bo 55.3
Z.	-ro 43.5	-mo 51.2	-bo 42.3

Three of the subjects, A., W., and Z., ascend in length of tappings as the feeling tone ascends. Three of them, B., L., and T., all give the medium stroke to the experiment they found in the middle degree of pleasantness but all three also ally the greatest degree of pleasure to the least amount of motor discharge. The other two, F., and N., show no correlation at all.

The next two experiments were the combinations de-ho, and ho-de (both long vowels). From graphing the objective results it appeared that ho-de produced on the average a greater motor output than did de-ho. Also the curve of the latter rises and falls,—from the first to the middle a rise, and from the middle to the end a descent; this was general for all the subjects: some reported a little exhilaration, strain and the like, but no feeling of fatigue, or exhaustion. The ho-de curve,

on the other hand, rises almost continuously from start to finish, with a remarkable rise on the fourth foot of the fifth group, and a no less striking descent on the last accented syllable of the series. But the last three groups show the same general tendency,—that of emphasizing the motor prominence of the fourth foot of the group. The first group of either, however, shows almost the same kind of form, which may be due to the persistence of the motor "set."

Three of the subjects, A., L., and T. preferred ho-de; in each case the tapped strokes were longer for the more pleasant; but in the former experiments, only one of them, A., showed this feature. All the other subjects, B., F., N., W., and Z. manifested a preference for de-ho; all but N, as mentioned above, tapped shorter strokes while reciting it. Four of the subjects found the vocal construction caused by the "-de" an unpleasant feature. But inasmuch as there was no objective standard of intensity or other vocal quale which was to be followed, the matter of constriction cannot be raised to a very high importance. One can say "ho-de" with countless degrees of energy and the like, and usually no subject intensified an unpleasant sensation; rather was the voice weakened and lowered to avoid it. On the same day, also as de-ho and ho-de were given, the combination ra-fo (both vowels long) was given. The explosive character of the f tended upon repetition to destroy the pleasantness with which it started out.

The graphings showed a remarkable steadiness of motor reaction for this combination until the last group of five iambics was reached.

The next two experiments were de-sto, and sto-de (vowels both long). Curiously enough, the differences in the amount of motor discharge did not appear until the fourth and fifth groups, and while the ho-de graph kept rising after the third group, and de-ho fell, here the case was altered completely; de-sto showed an ascent, but in the middle of the line only (!); but again, the accented O produced a slower reaction than did the E. One must remember, of course, that not only is the accented syllable different in each of these four experiments,

but also is the unaccented syllable. Furthermore, the subjects reported that not only did the iambic attempt to become a trochee, but the unaccented syllable also tended to demand an accent!

Correlating the feeling-tone with the motor discharge of these two experiments, we find that subjects A. and F. tapped longer strokes for the pleasant than for the unpleasant experiments; N., W., and Z. reversed this; L. tapped longer strokes for the unpleasant than for the indifferent, while B. and T. tapped longer strokes for the pleasant than for the neutral. A comparison of these results with those given previously shows very little constancy.

The Psycho-Motor Effects of N

The next seven experiments were constructed to ascertain the effect of accented N; the unaccented syllable, "be" (short e) was chosen because it seemed to be about as explosive as N, and thus would be a good balance for it. The experiments were: be-ne (e short), be-ne (e long), be-ni (i short), be-ni (i long), be-na (a long), be-nu (u short) and be-noo (oo long). N is also a much used sound in the language. Seeing that these experiments furnished a better body of material than any pairs or triads which had preceded, it was decided to correlate according to the mean, the mean variation, and the range. Introspectionally, N appeared to arouse an attitude of negation. This group of experiments also appeared as the conjugation of a verb, and took on at once with most of the subjects a distinctly "oriental" character. The N dominated consciousness, in spite of the changing final vowel. The experiments were all given on the same day; which may also account for the following constancy in numerical results.

Rank list. Average of the tappings for each subject.

Subject	Be-nĕ	-nē	-nĭ	-nī	-nā	-nŭ	-nōō	Variation
A.	b	b	c	c	b	b	b	2
B.	h	h	h	g	g	g	g	3
F.	e	e	e	d	e	d	e	2
L.	d	d	d	e	d	e	d	2
N.	g	g	g	h	h	h	h	3
T.	f	f	f	f	f	f	f	0
W.	c	c	b	b	c	c	c	2
Z.	a	a	a	a	a	a	a	0

If, however, we take the averages of the tappings for the pleasant, unpleasant and neutral experiments, no such harmony is manifest. As follows:

	Average of			P U N arranged in
Subject	P	U	N	order of magnitude
A.	52.9	53.3	51.4	U P N
B.	78.0	76.7	80.4	N P U
F.	62.9	62.4	65.0	N P U
L.	62.3	62.5	65.0	P U N
N.	78.5	80.8	—	U P —
T.	68.0	68.1	65.2	U P N
W.	53.8	—	—	— — —
Z.	46.0	49.1	—	U P —

But even if no judgments of unpleasantness or neutrality were made by some of the subjects, yet the above table shows that when such judgments were made, it was not at a time when the tappings were the longest; one is again at this place referred to Fere's "sensation et mouvement", *op. cit.* Where comparison is possible in these above citations, rarely did the pleasant feeling tone go with the longest tapped strokes. The balance hangs almost evenly between neutrality and unpleasantness in this respect.

The rank lists of the mean variations, hereafter denominated by M.V. and of the ranges, that is, the millimetric distance between the longest and the shortest tapped strokes, denominated later by Rnj, show no positive correlation. In this instance, also, the averages of the M.V. and of the Rnj. for the P., U., and N, experiments is hardly significant.

The graphs for these experiments showed that be-nĕ and be-nē are similar in their capacity to arouse equal amounts of motor discharge. The average difference is but 2mm. All things considered, the increase of motor output was fairly steady from start to finish. Benĭ and Be-nī showed a less increase from start to finish and in the third and fourth group of five iambics stood somewhat apart. There was a general rise in be-nŭ, but be-nōō fell almost precipitously at the close. Be-nā tended to duplicate be-nĕ and be-nē. These differences can hardly be correlated with those of feeling tone, for the be-nĕ was found to be pleasant by 3 persons, Unp. by 4, and indifferent by one; be-nē, which followed it quite faithfully in the graph, was

chosen pleasant by 7, and Unp. by one. Likewise, be-nŭ was found pleasant by two persons, Unp. by three, and yet this graph does not ascend at all like the other one or with so great an upward slant; moreover, be-nōō, which was chosen pleasant by all the subjects (including the 7 who chose be-nē as pleasant), did not produce the same kind of a graph in appearance as did be-nī. Furthermore, there was no report from the subjects that they felt the finger strokes getting longer or shorter in any such way as these graphs indicate they must have done. And every one of the subjects contributed to the increases and decreases. One can but conjecture then, that some of the neural currents find their way out of the central system along that motor channel which is already in use, without making their functional nature known to the introspective consciousness. It was unpleasant, also, for nearly all of the subjects to be aware of their lip and tongue movements; and while some of them actually did raise the pitch of their voices at the finish of be-nā and be-nī, yet they had no notion of it, much less of the fact that they were tapping in co-ordination with this general increase of effort. The only introspection they gave on this matter was "a feeling of difficulty" (*e.g.* with be-nĭ) and a "feeling of activity" etc. (*e.g.* with be-nī). That both of these should produce the same general increase of tapping is interesting.

The Effect of Long OO

The next experiments were of the same general character. Ro (long o) was chosen as the unaccented foot, and the long accented vowel was oo (long). Both being long, open vowels, a good balance was expected. Furthermore, the long oo vanishes quite readily into a long o, preceded by R. Unlike the former group, which was devised to study the effect of accented N, this group intended to bring into prominence the mouth resonances, rather than the articulation pressure of the consonant N. The following consonants, in the following order, were prefixed to the accented long oo: B, M, V, TH (sonant), D, Z, SH, J, L, and G. As usual, the iambic decasyllabic line was employed, and repeated five times.

From the introspection given for these experiments it was found that the long vowels employed in them dominated the combinations and had a non-personal reference. Frequently the effect became soporific, and again, when the consciousness of facial expression involved while reciting them became observed, the subjects were inclined to call the emotion thus induced one of "supplication" or "complaint." None of the consonants attached to this vowel ever became at all "hard," or difficult to say.

The rank list for the mean of these experiments.

Experiment / Subject	Ro-boo	-moo	-voo	-thoo	-doo	-zoo	-shoo	-joo	-loo	-goo
A.	d	e	e	e	f	d	e	d	e	f
B.	e	d	g	g	d	f	f	f	f	e
C.	i	i	i	i	i	i	i	i	i	i*
F.	f	f	c	d	e	e	d	e	d	d
L.	b	c	b	b	b	b	c	b	b	b
N.	g	h	f	f	h	g	g	g	h	g
T.	c	b	d	c	c	c	b	c	c	c
W.	h	g	h	h	g	h	h	h	g	h
Y.	a	a	a	a	a	a	a	a	a	a†

Comparing these ranks with those of the be-nī type of experiment and with only those subjects who took part in both, we find them showing the following divergences from a steady position:

Be-ni, etc., ...A. 2, B. 3, F. 2, L. 2, N. 3, T. 0, W. 2.
Ro-boo, etc., ...A. 5, B. 6, F. 8, L. 2, N. 5, T. 3, W. 3.

The first group represented here contained 7 experiments, the second, 10. One can expect a wider latitude of variation in a greater quantity of material. F., alone seems to have increased the ratio of divergence more than would be expected. It was noticed, also, that the organic stirs which some of these experiments, like, for example, Ro-thoo set up, was not shaken off by him (F.) until several of the subsequent experiments had been performed. Besides, -moo and -voo had disturbed his original position in the ranks, which was "f." He never afterwards regained it in this set of experiments.

The introspection for the above experiments contained many expressions of "feelings of activity," "struggles," "quiet states,"

* Subject C. now begins to tap the longest strokes of any and † Subject Y. remains in the lowest position. It is the rank of the other seven subjects, who varied the length of their tappings most and whose tappings are nearer alike in length which needs to be considered especially.

and so on. Let us compare these with the amounts of motor discharge in the tappings:

A. felt "-moo" to be easy, and "thoo" to be a struggle; and the M. for -moo is greater than for -thoo; again, in -loo, he felt activity, but the M. for -loo is not as high as it is for -shoo, -joo, and -goo, in each of which there were unpleasant mouth sensations. B. felt -joo to be the most energetic, and his M. for this is the highest of the series, 94.8; -thoo, which brought visual imagery of a dense crowd, was accompanied by a M. of 94.0; -zoo, with "openness," has an M. of 91.0; but while with th, "crowdedness" is correlated with 94.8 mm., "sultriness" in the imagery of -doo is correlated with only 77.6 mm. in the mean of the tappings.

C. shows some nice correlation between energetic and passive states in connection with -boo, -moo and -voo; but -loo is higher in the M. than -joo. F. gave the lowest of his M.'s to -voo and -thoo, which he found the most difficult to say, while in the sounds which brought a feeling of activity, he taps the longest strokes. L. does not seem to offer correlation either way. N. during states in which activity is felt, taps longer strokes than when some restraint is manifest; *c.f.* -voo, -doo, -zoo and -loo as compared with -boo, -thoo, and -joo. T. and Y. do not seem to furnish any definite correlations. W. taps variously for the energetic sounds, yet gives a M. of 99.8 to -zoo, which did not seem to appear energetic to him.

Thus the three factors of "free activity," "restraint" and "quiet ease" do not correlate with the amounts of motor discharge in any way as one might expect. Three classes of subjects are evidenced in the above records;—those who tend towards relaxation in the finger when they feel it in the imagery or in the utterance of the sounds, those who do the opposite, and those who vary throughout the experiments. But it is perhaps too early in the work to make any general statements.

Correlation of feeling-tone with motor discharge
Experiments: ro-boo............ro-goo, as before

Subjects	Pl.	Unpl.	Neutral	
A.	83.6	84.2	84.9	N U P
B.	89.3	77.6	85.7	P N U
C.	103.1	108.8	109.2	N U P

F.	85.6	79.6	—	P U —
L.	61.4	64.2	63.0	U N P
N.	93.6	90.4	—	P U —
T.	85.5	76.1	—	P U —
W.	96.0	—	88.8	P N —
Y.	46.6	46.0	—	P U —

This seems to give a decidedly different sort of result from that of the Be-ni type of experiment revealed with respect to the length of the tappings during the pleasant experiments; but if the single experiments are taken into consideration, it will be found that while subjects A. L. T. and W. do tap the longest strokes for the most pleasant of the pleasant experiments, yet the other subjects do not do so; B. C. F. and N. show no preferences, while Y. taps the shortest. But this division of the subjects into classes does not run parallel with the above division into classes on the basis of motor output and feelings of restraint, activity or quiet ease. But until we come to a set of experiments in which each one of the subjects is represented in all three feeling tones, it is hardly fair to pit one set of results over against another to the detriment of either. It may well be that the continuance of pleasant states or of other kinds has its own special effect upon the motor resources.

Considering the three rank lists, M., M.V. and Rnj. together, find that the number of aberrations from a steady position is very great, and only the following remarks are appropriate:

1. Subjects C., F. and N., approach and sometimes maintain some degree of regularity in the Mean Variation and in the Range, yet only one of these, C., remained steady in the Mean rank list. Here, in the M.V., this subject has four f-positions and in the Rnj., three g-positions, with a general tendency to maintain them. Subject F. who had eight displacements in the Mean rank list, steadies himself with three h-positions in the M.V. rank list, and with three g-positions in the Rnj. rank list, but only in the latter does he tend toward making that letter his moorings. Subject N., with five displacements in the Mean rank list, shows here steadiness in the M.V. list, tending toward an a-position, and in the Rnj. list his tendency is toward maintaining the same position also. But Y, who was absolutely steady in

the Mean rank list, here shows only three h-positions in the M.V. and but three c-positions in the Rnj. rank list.

2. Most of the other subjects, who tended toward some steadiness in the Mean rank list, here are scattered up and down the scales in complete disorder.

Correlations were shown before between the feeling tone and the averages of all the tappings for the pleasant, unpleasant and neutral combinations. There follows a similar table, showing the correlation between the feeling tone and averages of all the mean variations and ranges of all the tappings during the various feeling tone states.

(Repeating the former correlations with the mean.)
Experiments: ro-boo............ro-goo.

Subjects	Pleas.	Unpl.	Neut.	(Mean)	N U P
A. M.V.	3.1	3.4	2.4		U P N
Rnj.	18	19	12		U P N
				“	P N U
B. M.V.	3.7	3.2	4.1		N P U
Rnj.	20	13	19		P N U
				“	N U P
C. M.V.	4.5	3.7	2.9		P U N
Rnj.	19	24	16		U P N
				“	P U*
F. M.V.	3.5	3.0	—		P U
Rnj.	20	18	—		P U
				“	U N P
L. M.V.	3.5	3.4	4.9		N P U
Rnj.	18	17	23		N P U
				“	P U
N. M.V.	2.2	2.9	—		U P
Rnj.	12	14	—		U P
				“	P U*
T. M.V.	3.8	3.4	—		P U
Rnj.	20	19	—		P U
				“	P N
W. M.V.	3.0	—	2.7		P N
Rnj.	16	—	17		N P
				“	P U
Y. M.V.	3.1	3.0			P U
Rnj.	17	22			U P

* Where only two kinds of affective judgments are made, of course the possibility of correlation is better, but even chance would give as good correlations as N., W., and Y. show.

The graphs for these experiments showed an entirely new character in the visible record of the average of the tappings for all the subjects. With few exceptions, the rise is only initial, but not a great deal of importance is to be given to the first group of five iambics in any of the experiments, because no preliminary tapping was done by any of the subjects; they all began to tap and recite at the same time. The averages of the Be-ni type of experiment were all below 70 mm.; these are all above 77 mm.; evidently all the subjects got more familiar with the work. Indeed, all of them seem to have by this time passed the period of the "Anregung," as can be easily demonstrated from the tables which are to follow. It remains to be seen whether the subjects respond to the material of the experiment in such a way as to furnish correlations between feeling-tone and motor discharge in point of Mean, Mean variation and Range that will be of any service in determining the psycho-motor effect of the speech elements in poetry. Referring to the graphs again, it appears that the vowel OO swallows the consonants which precede it, and to produce in the drawings the visible effect of OO rather than of B, M, TH and so forth. It remains to be seen whether the other vowels to be experimented upon perform this same usurpative function or not. It will be remembered that ŌŌ dominated also the introspective consciousness in these experiments.

The Effect of Long E

The next ten experiments were devised to exhibit the effect of long E. The unaccented syllable was "la" (given as the Italian A, but it immediately became the neutral vowel).

In general, the effect of "E" was to produce feelings of tension, and as a long vowel, it was thought to take decidedly less time than either O or OO. Some of the subjects tried to "put force into it," but did not succeed; it appeared to cause restraint, rather than the "expected sense of outward control." All of the subjects called its pitch very high and not at all like the effect of most words containing long E's. It also appeared to be more modified

by the consonants preceding it than were the vowels in the other previously given experiments.

From constructing the rank lists for the mean of the tappings for these experiments, one sees greater variation from a steady position than with either of the two previously given groups of experiments. As follows:

Be-ni	A. 2	B. 3	C. 3	F. 2	L. 2	N. 3	T. 0	W. 2	Y. 0
Ro-boo	5	6	8	8	2	5	3	3	0
-be	10	11	8	9	3	7	9	3	0

Should we ask whether the change in the rank for each subject denotes a change in the feeling tone, the answer is doubtfully given either way. Y. found all these experiments pleasant, and keeps the same rank, but this subject's tappings are way lower in length than any of the other subjects'. W., who finds the last nine of these experiments pleasant and who varies very little in his position in the ranks, may be said to be fairly constant, but subject B., who also found the last nine experiments pleasant, varies his position in the ranks more than any of the other subjects (11 points). L., who is quite steady, varies his position even when he finds consecutive experiments are equally pleasant or otherwise; while N., who finds the first eight experiments pleasant varies most during the first part of the rank list.

Let us examine once more the averages of the tappings with reference to feelings of activity, hindrance and the like. A. felt a strain while reciting -fe, and his average is low; -ke and -le, which were felt to be active, show high averages. C. found -ne more energetic than -le, but tapped shorter strokes for it; -ge he found to be "powerful," and his average tapping is the highest for this sound. But -che is also quite active, and yet the average of the tappings is low. He thought he was tapping very long strokes for -the, but he was mistaken. F. began to feel strain sensations with the recitation of -ne, and from this point on he taps longer strokes; he called -ke less free than -le, and taps longer strokes for the latter sound. When L. found -ke a "hard" sound, his tappings were lower. Usually, the more "harmonious states of mind" brought the lowest averages for N.'s tappings. But when W. felt the freest, his tappings were the longest. Sub-

jects A., F., N. and possibly W. seem to be keeping quite constant; they tap the longest strokes in the freely active states, and vice versa.

Correlation between feeling-tone and motor-discharge, with respect to the mean of all the experiments, grouped under the three degrees of affect, P., U., and N.

	Experiments: -be	....	-ge.	
Subjects	Pl.	U	N	
A.	85.0	81.3	85.0	P N U
B.	83.0	—	87.4	N P
C.	93.1	85.6	86.6	U P N
F.	81.5	77.0	—	P U
L.	68.3	74.8	65.5	U P N
N.	88.5	—	90.2	N P
T.	79.3	76.2	78.0	P N U
W.	94.8	91.8	—	P U
Y	50.8	—	—	

Comparing this with the correlations for the -boo experiments, we find F., L., T. and W. somewhat similar in their preferences, but the other subjects vary exceedingly. L., indeed is the only one giving three judgments who duplicates himself.

Of all the subjects, Y. appears the most constant all the way through. N.'s ranges rank fairly steadily, but the Mean is not constant. W. and L. represent the best averages, after Y. C., who varies much in the F.T. as the experiments proceed, also varies much in these rank lists, but other subjects do not correlate in the same way.

Correlation between feeling tone and the averages of all the M.V.'s and Rnj.'s for the various experiments (together with the previously given data for the Mean).

	Experiments: -be	....	-ge.		
Subjects	Pleas.	Unpl.	Neut.	(Mean)	P N U
A. M.V.	4.3	5.4	2.6		U P N
Rnj.	23	21	13		P U N
				"	N P
B. M.V.	4.1	—	3.0		P N
Rnj.	48	—	11		P N
				"	U P N
C. M.V.	3.9	2.7	2.3		P U N
Rnj.	21	19	20		P N U
				"	P U
F. M.V.	3.9	3.2	—		P U
Rnj.	16	18	—		U P
				"	U P N
L. M.V.	3.4	3.7	4.8		N U P
Rnj.	15	16	18		N U P
				"	N P

N. M.V.	2.3	2.1	—		P N
Rnj.	21	11	—		P N
				"	P N U
T. M.V.	4.2	3.4	4.6		N P U
Rnj.	21	14	16		P N U
				"	P U
W. M.V.	3.6	3.5	—		P U
Rnj.	23	21	—		P U
					———
Y. M.V.	2.8	—	—		———
Rnj.	14	—	—		———

Here W. alone remains constant. All the rest vary almost as much as is possible with three permutable terms.

Something must be said now in regard to the last two sets of experiments in point of constancy in tapping during all the pleasant, unpleasant and neutral states. We observe that the final average of the mean, mean variation and the range do not adequately represent in most of the cases the general results. If one studies the variations from these averages, he will see that especially in the "pleasant" experiments, there is almost no confidence to be put in these figures as representative. It is not so much so in the case of the "unpleasant" experiments. Space does not permit a full review of this interesting point, but *in general, the pleasant states have more varied ways of representing themselves in the tapping than do the others.* The subjects frequently show that there is more variation from the mean of the "pleasant" tappings when there is no interruption in the affective tone as the list precedes, than when some other condition is manifest. This is very curious. And the objections that might be brought against any such method of experiment seem now to have plenty of reasons for their existence. Some might say that there should have been more careful judgments on the degrees of pleasure, to obtain a more accurate correlation, but it was deemed a very arbitrary matter to oblige the subjects to say "pleasure 1, 2, or 3" when they did not feel such a difference to be manifest.

Our next interest is in the graphs for these long E experiments. Ke, -ne, -ve, -me, and -le all start stronger than do the others, and also move straight across the page; while the others ascend fairly well together, but end in different degrees of strength.

The "scatter" of the first group of these graphs is greater in the second and third groups of iambics,—that of the others (the -be, -ge, -the, -che, and -fe) is prominent only in the last two groups. One might say that L, M, N, and V, being pleasant, had here shown positive correlation between pleasantness and motor discharge, since they are all lower than those of the most unpleasant experiments, those employing K, G, B, and TH, but -ke is in the group which shows the less motor discharge. Also -che, which everybody found pleasant, is next to the very topmost graph of the lot, which means that its average is to be placed with the other pleasant experiments. Ranking the experiments in a descending order of pleasantness, below which are the final averages of all the tappings, it can be shown, that with the exception

Exp.	-che	-le	-ne	-me	-ve	-fe	-the	-ke	-ge	-be
Av.	80.2	85.8	82.8	83.2	82.0	78.6	81.2	86.6*	78.4	78.4

of -ke*, the correlation runs positive with the pleasantness. As for -ke, it was chosen as indifferent by two of the subjects. But this apparent correlation may be due to the tapping of but one subject, W., who gave the longer tappings to the pleasant combinations.

The next experiments to be tried were devised with a view of discovering the effect of the "aw" sound. They were five in number. The unaccented syllable was De, (long E). Aw was preceded by these consonants: f, th, t, n, and g.

Introspectively it proved to appear pitched very low, to have a tendency to become nasal; not very musical, but arousing more organic stir than any sound previously used.

The rank list for the Mean of these experiments is, with symbols P, U, N indicating the feeling tone, as follows:

Experiment:	-faw	-thaw	-taw	-naw	-gaw
Subject					
A.	d-P	c-U	c-P	c-P	c-P
B.	f-P	d-U	f-P	f-P	h-P
C.	g-P	g-U	e-P	h-U	i-N
F.	c-N	e-P	e-P	d-U	e-N
L.	b-P	b-U	b-P	b-U	b-N
N.	h-P	h-P	g-P	g-P	f-P
T.	e-P	f-P	d-P	e-N	d-N
W.	i-N	i-U	h-P	i-P	g-N
Y.	a-N	a-N	a-N	a-N	a-N

Notice here that subject Y. would hold position -a- in the ranks, regardless of feeling tone; and that L., whose position in the ranks is -b- in these experiments, shows here lower tapping averages than he has for some time. It is hardly possible to make any statement about these ranks, except to say that the subjects are all more anchored to one position than in the case of either the Ro-boo or the La-be experiments.

In regard to feelings of effort and activity, C. described -naw as requiring effort, but the average for this experiment is almost the lowest of the series. -Taw, which gave a feeling of activity, is correspondingly high, but -thaw, which affected him the same way, fails to show in these averages; -faw, also requiring effort, is parallel in effect to -naw. The other subjects do not furnish enough examples to make correlation exact.

Grouping the above results according to feeling tone, and taking their averages, we obtain:

Subjects	P.	U.	N	
A.	64.9	66.7	—	U P
B.	80.9	73.6	—	P U
C.	88.6	85.3	97.8	N P U
F.	76.4	71.3	70.5	P U N
L.	57.8	55.0	58.0	N P U
N.	86.6	—	—	— — —
T.	75.0	—	73.5	P N —
W.	90.6	97.1	87.2	U P N
Y.	28.9	—	—	— — —

which, as results along this line, are not paralllel with any that have been obtained before.

The rank lists for the M.V. and the Rnj. show that of all the subjects, only W. and Y. keep some sort of anchorage in them; the rest vary indiscriminately.

Grouping (and averaging) all the Means, Mean-variations and Ranges according to feeling tone, we obtain the following:

(Order of greatest to least)

Subject		
A.	M.	U P
	M.V.	U P
	Rnj.	P U

B. (as above)	P U P U P U
C.	N P U P N U P N U
F.	P U N N U P N P U
L.	N P U P U N N P U
N.	all P
T.	P N P N P N
W.	U P N P U N U P N
Y.	all N

From the graphs for these experiments it appears that -gaw ascends steadily; -ge, in the preceding series, on the other hand, maintained a horizontal position. -Naw and -ne are likewise opposite in tendency, indicating some comparison in regard to these consonants. But -faw and -fe show the very opposite traits, as well as do -thaw and -the. One is tempted to correlate with the articulation-character of these consonants, but the amount of experimentation is as yet too meager. However, one thing more may be noticed, and that is that all of these -aw experiments but one, namely -naw, show in their final averages that the vowel "aw" tends to swallow up the consonants, in a way that the vowel "e" never did. Time did not permit any further experimentation with this vowel sound; furthermore, it is not a very important one in the tables of sound frequencies for English poetry. For equal bulks of material, nevertheless, and for those consonants which were used alike before accented -aw and -e, it is not idle to point to these results as showing something quite significant in the psycho-motor effect of the speech elements of poetry. Any one can see that the whole matter is one of amazing

complexity; later results may induce some sort of generalization of a specific character, but whether pro or con the matter of vocal valences, cannot be foretold at this time.

Experiments Upon the Four Most Used Long Vowels in English Poetry: A, E, I, O

We next undertook an extended study of the psycho-motor effect of the long vowels A, O, I and E. Ten subjects took part in the experiments.

The experimental material was made on this plan: The unaccented syllable was "la" (neutral vowel), and the various consonants were prefixed to each of the above vowels to make such combinations as "La-BA," "La-DA," "La-CHE," etc. there were twenty-four experiments on each vowel, which at the same time were experiments on each of the consonants employed; thus we had four experiments in which the consonant B was used, and so on for all the series. The experiments were all given to each of the subjects in the same order, at the rate of about eight or ten an hour.

The last two experiments in each series of twenty-four are slightly different from the rest; in the tables presented later they are called A, A2, O, O2, etc. The twenty-third experiment in each series, A, O, I, E, consisted simply in reciting the open vowel five times in a group and for five groups, filling in the unaccented syllable subjectively. Experiment number twenty-four in each group is a line of verse in which all the accented vowels are the same, thus: A2 is the line, "The gray and rainy April makes the May." O2 is "The homeless ocean moaning o'er the shoal"; I2 is, "The dying fire lights the silent sky," and E2 is "And dreaming seem to hear the weary sea." No such lines exist in poetry, but they served the purpose in hand.

It was found by introspection that the characteristic thing about the long A was its "flat and uninteresting" quality. It was by no means energetic, and when liked, it was termed "soft and quiet"; vocally it was felt to be directed downwards rather than upwards. As far as the vowel-vanish is concerned, it was so little noticed by the subjects that we need not mention it; of course

the repetition of the same iambic foot brought it so closely into contact with L in the unaccented syllable, as almost to nullify the effect of the vanish.

One rather remarkable thing was noticed in the numerical results for the A2 experiments: The mean of the tappings for every subject in this experiment drops below what it was for the previous experiment, A; with most of the subjects, also, it is lower than their average for all the other A experiments. Thus an influx of consonants, to say nothing of meanings, tended to reduce the lengths of the tappings. Changes in the apperceptive consciousness appear to induce changes in the motor setting.

O, from the introspection given upon the experiments concerned with this vowel, was more easily said than A, directed from the mouth more horizontally, more of an object of the esthetic consciousness, and more associated with the wind and water sounds of nature than the preceding one. Consciousness had more play with regard to O than A,—one could inspect the fringes and return to the focus, or maintain disparate foci quite easily during its recitation.

The character of the long I was found to be considerably more intense and forceful than that of A or O. Also the diphthongal character was very poorly concealed under the constant recurrence of the unaccented consonant. But I is a true diphthong and the introspection thus faithfully gives a prominent place both to the E-vanish and to the Italian A with which it begins. Its pitch seemed at once higher, its utterance less smooth, and the mouth movement more conscious than that of the preceding vowels; the drop and lift of the lower jaw was ever consciously prominent. It was frequently remarked that this vowel had very little connection with feelings of personality; the labial consonants had very much more to do with one's self than did the other consonants, and all felt much more intimate than did any of the vowels.

E was the most intense of all the vowels, feelings of strain at once appearing; but it was also more easily controlled by the muscles of the vocal apparatus than was I. Not so resonant as

the O, but it had far more "color" than the A. Reference was always external, the word "he" appearing to be thoroughly onomatopoetic. The tense condition of the mouth during its utterance often gave a feeling of weariness, as the position of the cheeks, lips and jaws is more rigid than in the case of the other vowels experimented upon.

If one should ask how these four vowels stand in the order of pleasantness, the answer is that O was chosen pleasant 126 times out of 240 judgments, I 123, E 120, and A 119 times. The consonants were preferred in the following order: R (28 out of forty judgments), L 27, N 27, V 25, M 24, B 24, D 23, Z 22, Ch 21, F 20, P 19, W 19, J 18 K 18, S 18, T 18, Th 17, St 17, H 15, Q 15, G 14, and Sh 12. One is referred in this connection to an article in the American Journal of Psychology, 1912, by Louise Roblee and M. F. Washburn, on the "Affective Values of Articulate Sounds," in which quite similar results are brought forth; the judgments of pleasure and displeasure were in general confined to the final consonants and vowels, and many more sounds were used by these experimenters than we have employed in the above experiments. But that S and I are quite netural in character, as the above-mentioned article indicates, we have not found to be the case in our own work. I was very insistent, and S became the basis for more unpleasant judgments in the transmogrifications than any other single sound in the language.

If we compare the consonants in the order of their pleasantness with their order of frequency, as given in the introductory paragraphs, it will be seen that the two orders do not entirely correspond; nevertheless, it is plain that the pleasanter of the sounds, as found in the brief sampling of the consonants, are those which occupy the positions of higher frequency; had all of the consonants been combined with all the vowels, the discrepancies might have been less. Three factors seem to militate against pleasantness in the pronunciation of a consonant: breathiness, vigorous movement of the lips, and the employment of the ends of the tongue in articulation.

A correlation between feeling tone and motor discharge was

found in the following way: If one arranges the averages of all the tappings for each of the experiments upon any one of the vowels in the descending order of motor output, and places side by side the same twenty-four experiments arranged in the ascending or descending order of pleasantness, it will be seen that in the case of the A-experiments that the more unpleasant were correlated with the greater expenditure of motor energy and vice versa. So with the other three vowels, the O, I, and E. This is exactly in line with what was found in the case of most of the earlier experiments in this investigation. Differences in one to one correspondence appear, however in the case of each of these vowels: with the long A, there are seven such correspondences; with O, there are eleven; with I, but two, and with E, five. The average displacement for the others is with the A, nearly nine points; with O, eleven; with I, eight; and with E, nine. It was also to be learned that the explosive consonants aroused the motor consciousness more than the softer and more liquid sounds. Besides, those sounds requiring the more facial movement while uttering them arouse the more general somatic activity.

Differences in the time taken to recite these experiments were not to be correlated with either of the above factors of affection or motor output; it is true that the more explosive sounds tend to be said very quickly, perhaps indeed, because many of the subjects tried to say them quickly to get done with them. But the liquids also went quickly, because they blended well together in the combinations,—indeed the whole line of five iambics often went like one ten-syllable foot, according to the introspective report.

As typical of the numerical results of these simple vowel and consonant experiments we next present the averages of the tappings by each subject together with the mean variation and the range, and also the rank lists for the above results in the case of the long O experiments. It will be noticed that most of the subjects change their position in these rank lists quite frequently: this will not mean that there was a corresponding change in feeling tone, but only in motor settings and motor arousal. With the

vowel, O, however, less variations from average position occurred in the case of each subject. The character of O from the introspective report is an interesting corollary to this fact: O was the most pleasant of the four vowels, and the play of consciousness about it was greatest on the side of introspection, but apparently not as regards the motory end of the matter.

The mean of the tappings for the long O experiments follows:

Subject	-Bo	-Do	-Fo	-Go	-Ho	-Jo
A.	86.2	85.3	92.4	90.5	88.2	80.7
B.	94.8	93.6	79.7	81.6	81.3	80.8
C.	110.0	106.3	105.1	105.6	105.1	104.5
D.	90.2	84.6	88.4	83.2	93.9	81.2
F.	90.2	96.8	96.7	92.6	92.2	93.8
K.	41.6	47.6	51.6	53.4	54.5	44.7
L.	77.6	79.0	71.4	62.1	62.5	67.5
M.	89.2	91.2	91.5	91.5	90.3	95.0
P.	126.5	125.2	115.4	120.8	120.4	117.6
S.	103.7	102.4	98.8	105.8	108.0	109.8
	-Ko	-Lo	-Mo	-No	-Po	-Qo
A.	68.1	80.5	79.7	65.0	91.3	88.6
B.	89.5	64.6	84.1	92.7	88.7	83.4
C.	103.2	99.6	101.7	111.5	107.1	111.1
D.	92.7	101.5	97.8	96.6	98.5	90.7
F.	94.8	87.8	90.6	89.5	82.2	90.2
K.	43.9	35.9	30.1	25.2	44.0	37.3
L.	71.8	70.9	65.3	66.0	72.2	67.5
M.	91.5	93.7	94.0	90.7	92.2	98.0
P.	116.1	117.8	115.4	121.0	124.1	127.8
S.	108.3	104.5	108.5	112.2	107.4	107.6
	-Ro	-So	-To	-Vo	-Wo	-Zo
A.	81.2	84.2	83.3	88.1	83.7	87.1
B.	95.0	91.6	91.1	89.3	95.0	91.8
C.	109.0	109.6	105.2	101.4	102.8	106.8
D.	94.4	88.0	91.2	95.9	96.3	96.0
F.	86.6	88.9	87.4	86.7	79.8	83.2
K.	67.5	55.7	37.2	42.1	44.9	42.8
L.	68.0	72.0	74.9	77.4	63.8	74.0
M.	98.9	88.8	92.8	90.8	90.7	91.7
P.	117.3	122.2	118.4	124.4	124.8	125.4
S.	111.9	104.4	110.7	113.2	113.6	113.7
	-Cho	-Sho	-Sto	-Tho	-O-	-O2-
A.	84.5	75.1	86.1	75.8	75.0	74.6
B.	77.4	81.8	86.4	92.6	82.7	101.4
C.	105.9	107.5	105.5	100.2	106.7	97.4
D.	93.3	93.7	93.5	94.7	102.0	101.8
F.	96.8	97.8	93.8	84.8	93.8	95.2
K.	44.5	49.2	31.1	39.8	53.8	45.7
L.	74.1	70.0	78.8	73.1	58.3	71.8
M.	96.3	94.0	103.4	96.0	97.4	95.4
P.	117.8	118.9	122.7	125.4	121.1	124.2
S.	117.4	118.5	118.0	115.5	120.5	125.6

The rank list for the Mean: La-Bo, etc.

Subject	B	D	F	G	H	J	K	L	M	N	P	Q
A.	c	e	f	e	d	c	b	d	c	b	e	d
B.	g	f	c	c	c	d	d	c	d	f	d	c
C.	i	i	i	h	h	h	h	g	h	h	h	i
D.	e	d	d	d	g	e	f	h	g	g	g	f
F.	f	g	g	g	f	f	g	e	e	d	c	e
K.	a	a	a	a	a	a	a	a	a	a	a	a
L	b	b	b	b	b	b	c	b	b	c	b	b
M.	d	c	e	f	e	g	e	f	f	e	f	g
P.	j	j	j	j	j	j	j	j	j	j	j	j
S.	h	h	h	i	i	i	i	i	i	i	i	h

Subject	R	S	T	V	W	Z	CH	SH	ST	TH	O	O2
A.	c	c	c	d	d	d	d	c	c	c	c	c
B.	f	g	e	e	f	f	c	d	d	e	d	g
C.	h	i	h	h	h	h	h	h	h	h	h	f
D.	e	d	f	g	g	g	e	e	e	f	g	h
F.	d	f	d	c	c	c	g	g	d	d	e	d
K.	a	a	a	a	a	a	a	a	a	a	a	a
L.	b	b	b	b	b	b	b	b	b	b	b	b
M.	g	e	g	f	e	e	f	f	g	g	f	e
P.	j	j	j	j	j	j	j	j	j	j	j	i
S.	i	h	i	i	i	i	i	i	i	i	i	j

The mean variations for these experiments: La-Bo, etc.

Subject	Bo	Do	Fo	Go	Ho	Jo	Ko	Lo
A.	4.2	7.1	3.7	5.0	3.5	3.6	6.7	2.6
B.	4.6	3,2	3.1	3.1	3.8	4.8	7.2	4.7
C.	3.7	2.4	2.1	2.4	3.1	3.3	2.7	2.8
D.	2.1	5.6	2.6	5.2	1.8	5.0	2.8	2.2
F.	3.8	3.3	3.0	3.3	5.6	4.3	3.4	5.5
K.	4.1	4.9	4.2	3.4	4.1	4.0	2.9	4.8
L.	2.8	2.5	4.1	4.8	5.5	4.5	5.6	3.8
M.	3.0	1.6	2.8	2.2	2.3	2.4	2.4	3.4
P.	1.9	2.1	5.0	3.0	2.2	3.4	3.8	3.8

Subject	Mo	No	Po	Qo	Ro	So	To	Vo
A.	3.3	4.0	2.8	4.9	5.7	3.2	4.8	5.3
B.	4.9	4.3	7.3	5.2	4.5	5.8	5.1	7.0
C.	3.1	2.8	3.2	2.9	2.8	3.3	3.2	2.4
D.	1.4	2.2	2.9	3.2	2.5	3.6	1.8	3.9
F.	3.2	3.8	6.2	3.9	3.6	3.6	3.9	3.6
K.	4.4	3.7	3.8	4.8	5.6	4.3	5.4	4.4
L.	3.5	4.1	2.3	4.1	2.7	3.1	6.0	3.8
M.	2.4	4.2	3.3	4.0	2.6	2.9	3.4	4.2
P.	3.8	3.7	5.9	2.5	1.8	2.4	2.5	2.5
S.	2.6	1.7	4.0	2.6	2.2	4.6	4.1	2.5

Subject	Wo	Zo	Cho	Sho	Sto	Tho	O	O2
A.	4.1	4.1	5.4	7.1	5.2	4.1	4.2	4.1
B.	4.8	5.0	4.1	5.5	6.0	5.8	4.1	4.6
C.	2.7	3.7	3.0	3.3	2.5	2.2	3.0	2.8
D.	2.8	3.9	2.1	1.6	2.6	3.5	1.6	2.6
F.	3.0	4.0	3.2	2.7	2.9	4.7	1.9	3.8
K.	4.2	5.8	5.9	3.2	4.7	5.2	4.7	5.1
L.	4.3	4.3	4.8	5.6	4.5	5.4	5.7	5.8
M.	2.6	3.2	3.6	3.9	2.8	5.5	2.7	3.7
P.	2.3	1.2	2.0	2.9	2.9	1.2	2.1	1.9
S.	3.1	2.7	3.3	3.1	4.1	4.4	3.6	2.9

The rank list for these mean variations: La-Bo, etc.

Subject	B	D	F	G	H	J	K	L	M	N	P	Q
A.	h	j	g	i	f	e	h	b	f	g	b	i
B.	i	e	e	e	g	i	i	h	j	j	j	j
C.	e	c	a	b	e	c	b	c	d	c	d	c
D.	b	i	b	j	a	j	c	a	a	b	c	d
F.	f	f	d	f	j	g	f	j	e	f	i	e
K.	g	h	i	g	h	f	e	i	i	e	f	h
L.	c	d	h	h	i	h	j	f	g	h	a	g
M.	d	a	c	a	c	b	a	d	b	i	e	f
P.	a	b	j	c	b	d	g	e	h	d	h	a
S.	j	g	f	d	d	a	d	g	c	a	g	b

Subject	R	S	T	V	W	Z	CH	SH	ST	TH	O	O2
A.	j	d	g	i	g	g	j	i	i	g	d	h
B.	h	j	h	j	j	h	h	j	g	i	j	g
C.	f	e	c	a	c	c	f	a	c	d	b	e
D.	c	f	a	f	d	b	a	b	b	e	c	a
F.	g	g	e	d	e	f	b	e	d	f	f	b
K.	i	h	i	h	h	j	e	h	j	j	g	i
L.	e	c	j	e	i	i	i	g	h	h	h	j
M.	d	b	d	g	b	e	g	d	f	c	i	d
P.	a	a	b	b	a	a	c	c	a	a	a	c
S.	b	i	f	c	f	d	d	f	e	b	e	f

The rank list for the ranges: La-Bo, etc.

Subject	Bo	Do	Fo	Go	Ho	Jo	Ko	Lo
A.	20	32	21	26	16	16	35	12
B.	24	14	18	16	17	20	27	25
C.	18	15	9	14	15	17	16	14
D.	11	28	12	30	12	22	20	11
F.	18	18	15	22	23	18	21	28
K.	18	22	16	19	18	23	29	21
L.	15	13	19	20	21	19	25	17
M.	14	9	13	10	10	11	16	16
P.	8	10	20	12	11	21	12	22
S.	19	22	24	18	20	8	15	26

Subject	Mo	No	Po	Qo	Ro	So	To	Vo
A.	23	23	15	23	22	15	29	25
B.	30	21	26	28	23	24	39	28
C.	11	15	14	15	11	23	17	14
D.	9	12	13	16	13	17	12	19
F.	24	19	28	17	24	13	20	18
K.	21	20	19	29	20	25	25	27
L.	18	16	21	24	14	18	27	22
M.	12	22	16	21	21	12	22	20
P.	19	18	30	11	12	21	14	17
S.	10	9	27	22	9	16	18	12

Subject	Wo	Zo	Cho	Sho	Sto	Tho	O	O2
A.	25	20	19	31	25	19	21	22
B.	32	21	23	25	30	30	18	26
C.	19	15	13	13	11	11	17	12
D.	13	12	11	7	15	17	7	10
F.	12	18	15	17	20	24	11	17
K.	28	28	26	12	18	22	21	23
L.	22	16	21	37	22	18	27	18
M.	14	17	18	19	21	23	19	21
P.	18	7	9	18	19	7	16	11
S.	20	14	14	11	24	33	20	20

The rank list for the ranges: La-Bo, etc.

Subject	B	D	F	G	H	J	K	L	M	N	P	Q
A.	i	j	i	i	e	c	j	b	h	j	c	g
B.	j	d	f	d	f	g	h	h	j	h	g	i
C.	e	e	a	c	d	d	d	c	c	c	b	b
D.	b	i	b	j	c	i	e	a	a	b	a	c
F.	f	f	d	h	j	e	f	j	i	f	i	d
K.	g	h	e	f	g	j	i	f	g	g	e	j
L.	d	c	g	g	i	f	g	e	e	d	f	h
M.	c	a	c	a	a	b	c	d	d	i	d	e
P.	a	b	h	b	b	h	a	g	f	e	j	a
S.	h	g	j	e	h	a	b	i	a	a	h	f

Subject	R	S	T	V	W	Z	CH	SH	ST	TH	O	O2
A.	h	c	i	h	h	h	g	i	i	e	i	h
B.	i	i	j	j	j	i	i	h	j	i	e	j
C.	b	h	c	b	e	d	c	d	a	b	d	c
D.	d	e	a	e	b	b	b	a	b	c	a	a
F.	j	b	e	d	a	g	e	e	e	h	b	d
K.	f	j	g	i	i	j	j	c	c	f	h	i
L.	e	f	h	g	g	e	h	j	g	d	j	e
M.	g	a	f	f	c	f	f	g	f	g	f	g
P.	c	g	b	c	d	a	a	f	d	a	c	b
S.	a	d	d	a	f	c	d	b	h	j	g	f

In measuring the ranges, it often happened that two or three subjects could have had the same position; re-measuring, however, or alloting to the subjects that position which they had previously tended to maintain, obviated the difficulty; for example, where subjects A. and B. were equally set for the position C in the rank lists, but had previously maintained positions B and C respectively, we assigned to them positions B and C, in order both to have ten positions, and to give each of them the benefit of the doubt. With differences of tenths of a millimeter as the basis for many of the correlations, it was not always easy to determine the exact status of affairs for any one subject with respect to another better than by the above method.

If one is again asked what changes of position in the rank list for the Mean denote, or even what changes in the average of the tappings denote, we are somewhat at loss to give a fully satisfactory answer; it is not due to a change in feeling tone so much as it is due to various manifestations of the motor consciousness during the continuance of the same feeling state. As was previously noticed in the first year's work, it is usually

quite a while after the onset of a new feeling state, that a change takes place in the motor manifestations. And insofar as we correlate with the introspective report as a basis, we find that the mean variation of the tappings made during pleasant states is greater than the mean variation of the tappings made during unpleasant or neutral states; thus pleasure is manifested, at least in this experiment, by more varied expressive means than are the other affective states of consciousness. The introspection in connection with the pleasant experiments is richer, the associative functions are more operative, and the general bodily and mental condition is more indicative of ever new and varied manifestations in those states in which fine esthetic feelings are present than in those which appear to indicate the presence of cloggings, inhibitions and mutually antagonistic impulses.

Graphing these experiments revealed the following characteristic differences between the vowels:

The ascending order of motor output followed the series as presented, A, O, I and E. This may, however, be due to practise alone. But within any group of experiments other differences are quite significant, especially if compared with the introspection as given above; the O-graphs showed the least scatter, the E and I the most. E and I also march straight across the page, while A shows an "Anregung" incessantly throughout the series. E and I are also spoken in a shorter time than are O and A, and besides, the O-graphs are all indicative of the fact that this vowel was spoken in more nearly the same time even though preceded by the various consonants than were the E and I. Here, in the case of O, steadiness of motor discharge, as evidenced by the fact that the vowel tends to swallow the consonants which precede it, is correlated with steadiness and evenness of introspectional content and attitude; with E and I, on the other hand, the exact opposite is the case. The number of factors involved is many, and the final result may perhaps be tentatively stated as follows: Quickness of utterance is correlated with greater motor output; strain in the vocal apparatus with unevenness of motor output; ease with which the vowel is spoken

dominating the strain-effect of the consonants; and a negative correlation between unevenness (though unfelt) in the motor output, and also amount of such output and the pleasantness as aroused in the introspectional conscious content.

From a different graphing of these experiments, four in a group, on the basis of consonants preceding the vowels, where in each group of four drawings, one finds those graphs together which show the differences between the four vowels under the influence of the same initial accented consonant, we found that in nearly all the cases the A graph is the lowest, frequently very much the lowest, while again, the O, E, and I graphs exchange positions of height and extent to some considerable degree. But this is quite natural,—if the O had been *by far* the pleasantest vowel, or the R *by far* the pleasantest consonant, we might have expected the R and O graphs to appear unique and different from the others, but the vowels are almost equally pleasant, a difference of but seven judgments of agreeability separating the O and the A (the extremes), and the consonants grade very gently from the most to the least agreeable. So it is perhaps correct to say that the different graphs represent the matter not so much from the vowel side as from the consonant side when we compare the graphs for any one vowel together but that comparing one of these large groups with another, we have vowel differences rather than consonant differences before us.

The introspection revealed the fact that entirely different states of mind were aroused according to changes in the direction of the attention; instructions were given to neglect the physical sensations and to think of the sounds as much as possible, in order to have constant conditions for all the subjects. But this does not seem to have worked very satisfactorily in many of the above cases; frequently, indeed, mixed feelings were reported; the subjects would say: "The sounds are not unpleasant, but I do not like to say them"; or, "The sounds as heard are all right, but the everlasting mouth movement is exceedingly hard to keep out of the focus of consciousness." Absolute restraint was impossible; it would also have been quite unwise, for we were study-

ing the motor as well as the introspective consciousness and to find out just what happened in apparent conflicts between the two, especially on the side of the affections, was considered just as valuable as anything else. It was thought better to let things take pretty much their own course in the matter rather than to be too severely restrictive. But that the introspection was not universally given on the same elements in consciousness is at once evident; whether it could be, whether one can abstract one element and keep it abstracted throughout the series is very doubtful indeed. And yet, when we compare the amounts of motor discharge for the different subjects, the question comes up: "What was it that was called pleasant or unpleasant?" Well, the only thing to say is that the whole experience extended toward this or that type of affective tone, and that is about all that can be said. And if that is insufficient, then some other method must be devised to experiment upon these simple vowel and consonant combinations than we have employed. One will also notice that the subjects talked about some of the combinations having a higher pitch than others,—unless the pitch was changed, subconsciously, of course, to relieve the uniformity, this is quite incomprehensible; surely the vowel A does not take a different pitch in connection with some of the consonants than it does with the others, and if it seemed to, it is not unlikely that this was an illusion due to the greater intensity required to enunciate the explosive consonants. And as there was no uniformity on the judgments of pitch, even among the two or three subjects who made them, it is hardly possible that the pitch judgments indicate anything objective.

One final point also needs to be emphasized; which is that the tendency to make words out of these meaningless experiments was super-strong with nearly all of the subjects. As one subject said in regard to the transmogrifications: "It tantalizes me dreadfully because the words I get out of them have such disjunctive meanings." So that some severe critic might call this whole work, "An experiment in the delayed associations of misspelled words." But following such caustic criticism, let such

a person suggest some better way than we have used to experiment on the psycho-physiologics of the sounds of the language, and thus help us out of the dilemma. We admit right at the start that the whole realm of psychological esthetics seems to be constituted chiefly by its difficulties.

SIMPLE EXPERIMENTS CONSTRUCTED FROM THE TABULATIONS OF SOUND FREQUENCY IN ENGLISH POETRY

In connection with the next two sets of experiments reference must be made to the previously mentioned tabulations of sound frequency in the poets. If one arranges these percentages in order of magnitude for each one of the poets, it will be noticed that certain sounds are almost equally prominent for all of them, especially in the unaccented lists; and here we refer to the short U, I and A. Of the accented sounds, the consonants, rather than the vowels appear to be common property, inasmuch as R, T, D, L, S and M usually stand at the head of the lists.

The next twenty-seven experiments were devised to show the effect of the most prominent of these accented and unaccented sounds. They nearly all contain two unaccented and three accented letters. But these combinations, unlike those which have hitherto been employed, usually end with a consonant, L, N, D and T predominating. Thus the body of sound produced by their utterance is something more solid than we have had before; and the organs of articulation exercise more control than they did in the case of the long, open vowels.

No single poet's preference for certain sounds is especially represented in these combinations; the whole twenty-seven of them merely exhibit the most used accented and unaccented sounds of English poetry "ueberhaupt." The introspections for these experiments, which were given in the following order, is of interest:

I. Ne-rol. (Iambic foot, vowels both short; repeated five times in succession for each of the five groups.)

Implies the joys of rustic work and pleasure; visual imagery of the fields in summer. Soft and musical; suggests rapidity of movement; imagery of some

May morning. Soft, drawn-out thing; not very active nor deep, but it has body. Very musical and easy to say; sounds like the ringing of a bell; slightly monotonous, but not dull.

II. Un-ral(e). (As above, metrically and in groups; short "u," long "a".)

"R" the best thing about it; seems slightly inharmonious and perturbing; no definite imagery. Not energetic; couldn't keep the word "unreal" out of mind. "Ral" gives a feeling of contraction; seems inefficient; thinks of the pattering of hail or of big water drops.

III. Id-rel. (Vowels both short.)

Sounds have a bell-like quality; seems to refer to some celebration. Hard to keep the two syllables apart. Became "id-well," "did-well"; dislikes the jump from the first syllable to the second. Musical, hopeful sound; keeps ascending in pitch.

IV. Ri-tin(e). (First "i" short; second, long.)

Visualizes self on the sea shore on a warm, summer day; feels the heat and his own body distinctly. Makes him frown. Seems narrowly concentrated in space. Musical; in major key; encouraging; calls up the word "time." Emphatic, but monotonous; gets nowhere.

V. Tu-lin. (Both vowels short.)

Energetic and poetic; visualized the sea; heard the wind and the sound of the breakers. Very easy and pretty sound to make; suggests a light, fleet movement. Seems rapid; "tu" is light; "lin" heavy; good combination of sounds; very easy to coördinate finger and voice. Soothing and quieting; a lullaby; the alternation of the vowels is charming.

VI. Ti-ren. (Both vowels short.)

Sharp and concise and easy to produce; but the "n" seems to negate the expected climactic character of it. The superficial gloominess of a rainy, indoor day implied; not very "deep" sound; visual imagery dark gray. Couldn't keep track of the counting. Forceful sound; calls up the words "to arms!"

VII. Ti-rel. (Vowels both short.)

Bell-like; musical and melodious; implies recreation; visualizes a country dance in the moonlight; slightly erotic. Energetic and speedy; runs together well; suggests the full pleasure of animal spirits. Just a happy little fool's song; jolly. Good lyric poetry; "It may be flip, but never mind"; the sounds run together beautifully. Exciting and exhilarating; feels the pitch to be very high; brings a joyful and exuberant feeling.

VIII. Un-dol(e). (First vowel short; second, long.)

Has distinct musical quality, but the tone is sad and mournful. Romantic, but doleful; recalls the "Niebelungen Lied"; implies the pathetic fallacy. Quiet and sombre; calls up the tolling of a bell; exceedingly passive thing. Means a mild lament, or self-pity; the nasal sensations almost become unpleasant.

IX. A-ren(e). (Short "a," long "e.")

Almost meaningless and nonsensical; seems to be calling someone by name. Not poetic; thought of things colloquial. More energetic than "un-dol." Very uninteresting and commonplace; "ri-tin" was intellectual; this is stupid. Has a romantic quality; seems like some amorous declaration; musical. A small sound; it is minor music; makes one quiet and thoughtful; might arouse pity and sympathy.

X. Ri-nad(e). ("I" short, "a" long.)

Something mournful about it; but not much to it. Induces a slow, passive state. Seems to stay way back in the mouth cavity; can't raise the pitch enough to make it effective. Seems contracted and nasal; has no life or activity to it; too inward. Emphatic; almost a battle cry; very dignified sort of a thing.

XI. Un-rin. (Both vowels short.)

Emphatic; the rhythm is easy and regular, but the nasal quality is not enjoyable. Something hopeless about it; seems like a cry; Shelley's poetry came to mind.

XII. Ti-ra. (First vowel short; second, long.)

Thinks of something like political excitement; "sis-boom-bah-rah" and Roosevelt prominently in mind. "It's just some conversation." Nice and quick; happy and joyous; expansive; suggested "hooray." Implies jubilant and exultant action.

XIII. Ni-dal. (Both vowels short.)

Reminds of very fine and pleasing music. Active and energetic; suggests the military. Calls to mind the girls of Biskra in the street of Ouled Nail. "It tumbles out of the mouth before you want it to"; implies following the line of least resistance. Something important and also impatient about it; implies hurrying.

XIV. Ri-leet. (Short "i.")

Like a bird song; bright and vivacious. Not very deep, but joyous; images a woodland scene in the summer; birds and squirrels plentiful. Feels hurried; thinks of the song of a lark. Thought of "relief," "rillet," etc. Very dainty, light and springy; something bright and feminine about it.

XV. Ti-reen. ("I" short.)

Thinks of the mightiness of nature; wild gray ocean and sea gulls imaged. The explosive quality of "ti" well counterbalanced by "reen"; it's like a ditty sung to oneself. This is romantic and "eulogistic"; might be a love sonnet, or some manifestation of devotion.

XVI. Ri-nel. (Both vowels short.)

Has a bell-like quality; "rin" is subjective; "el" objective. Like a bell; tranquil, but not solemn. Seems to swell in volume as it proceeds; good sound with which to call any one. Something personal, fatalistic, and strong about it.

XVII. Ni-lur. (Short "i"; "u" as in "fur.")

Seems deceitful, and slippery; too smooth to have any body to it. Implies a Byronic despair; visual imagery of a gray cold autumn sky. Difficult to say; gets way up in his nose; suggests peevishness; wanted to prolong the "lur" so as to get a firmer hold on the "ni." Hard to say; lacks body; felt almost tongue-tied. Calls to mind some foolish person, perpetually grinning; mouth sensations disagreeable. Very emotional; an intoxicating riot of sounds; full of color.

XVIII. Ri-dev. (Both vowels short.)

Very peculiar; thought of a hot, summer day; also some fiery, physically exciting passion obtruded. Unusual sound; "devil" the only thing that came to mind. Dramatic; alluring; wanted to make it impressive; something funereal about it. Has resonance, but gives a drawn-in, contracted feeling. Funereal and mournful thing; yet has musical quality and fascinates one.

XIX. Ni-rees. (Short "i.")

Very musical; sounds like whistling. Feels the "s" stops one short; like putting on the brakes suddenly while driving an auto. Mouth movement seems delicate; tends to fuse into "nireesnirees," etc., without stopping between the syllables; like singing a little tune to himself; feels contemplative. Sort of a "love motif"; imagery of a woodland scene, with birds and soft, quiet places. "S" softens, hushes, smoothes; very light and dainty sounds; "s" also seems like spreading something over a broad surface. Foreign sound; slightly wistful; yet gives a feeling that something is inevitable. Quieting, slightly monotonous sound; thought it descriptive of the waves on the sea shore.

XX. Un-reen. (Short "u.")

Something profound about it; a sad, unsatisfied cry, either sexual or spiritual. Sounds like a call for help; or else it is some exposition of an important theme. Doesn't allow one to expand; a climax foreshadowed, but not reached. Something romantic, supplicating and pathetic about it.

XXI. Ni-ral. (First vowel long, last vowel short.)

Imaged a big country fair, where everybody was having the time of his life; "ni-ral" is everybody calling everybody else. Called up visual image of Millet's "The Lark." Makes him keep his mouth open all the time; gives a cold feeling all over; the "i" seems like something pointed; almost deprecative.

XXII. Thi-ra. ("Th" sonant; "i" short; "a" long.)

Has much quality, but the lisping character of the "th" almost killed the feeling tone. The syllables do not seem to belong together; "th" irritates; seems like a lover's lisp. Peculiar mixture of sounds: "th" always repulsive; "ra" very fine; almost a case of mixed feelings. Difficult to say; seems like a scraping movement along the ground. "A horrid, tongue-tied lisp."

XXIII. Ne-mal. ("E" long; "a" short.)

Implies a superficial pessimism or complaint. Tends to become "nemel" and "nemalne" (trochaic); seems to be just a matter of daily conversation, buying and selling, and the like. Insistent and affirmative; "ne" is the disturbing factor. Implies maliciousness, anger or irritation; it climaxes into a veritable fury.

XXIV. Ri-naz(e). ("I" short; "a" long.)

Very subjective thing; "az" makes it so inward. Slightly energetic; imagery of a rainy day in the country. Slow, monotonous, sombre, deadening; demands much attention to keep saying it. Smooth, but lacks body; like the voice of a mediocre clergyman giving a nice, homely sermon. Quieting, harmonious quality to it; implies the pleasant acceptance of a situation, suited to one's abilities. It means homage to some Oriental monarch whose name is "Rinaz." A lullaby; something almost hypnotic about it; fascinating.

XXV. Ro-len. ("O" long; "e" short.)

Expresses activity, but a superficial kind. Active, and quick; rolls right along. Clear cut, vigorous and manly sound; personal reference to it. "Rol" should have the accent; hence it shuts off the effect of the intended iambic. Rather matter of fact and unimaginative. Rather strong and vigorous; tendency to anticipate the accent with the finger. Pleasant alternations of the vowels; "en" brings one right up standing.

XXVI. Thi-nal. (Both vowels short.) (Th surd.)

"Th" is the disagreeable part of it; something remorseful about it. Gives a blurred effect; the whole things seems to lisp. "Th" ruins the otherwise pleasant effect of "nal." Easy to say, but the "nal" is too nasal; it whines; reverberations of the sound felt throughout the face. An unimaginative, practical, downright statement of fact. Harsh, complaining, and unsatisfying; the pitch is too high to be pleasant.

XXVII. Ri-neen. (Short "i," long "e.")

Too nasal to be musical; refers to some one other than himself. Rather tiresome work; thought of rowing fast and hard for no particular purpose. Too nasal; the final "n" is the worst part of it; not so mature a sound as "rolen." "Neen" is cold and hollow; too low in pitch; makes one short of breath and demands great depth of voice; "ri" is by itself quite pleasant.

Even from these fragments of the introspection given in connection with the above experiments, it is plainly seen that the responses of the subjects to the material indicate that they had "gotten into" the business of introspection better than ever before. Much of it, is of course not pure introspection; but the instructions were only: "give me what is in your mind after you have recited this combination twenty-five times." In describing the effect of these sound combinations, then, if to say, "it is like

this or that" may not be introspection, yet it did not seem possible to obtain any other introspective results than the above. And yet, in the light of future experimentation, just this kind of answers upon the effect of the sounds in poetry seems to be the only thing one can obtain, and furthermore, the results obtained from introspecting upon passages of poetry transmogrified into meaningless jargon justifies to a considerable degree the method of introspection which most of the subjects employed. One thing more, also; the idea that the subjects would all introspect upon the physical sensations or learn to do so was quickly expelled from the mind of the experimenter; the threefold instructions,—to give feeling-tone, sensations, and imagery proved to be too autocratic; what we have in the above, typical introspection is mostly feeling-tone and association. However, inasmuch as most of the subjects did not like to think of the movements of the organs of articulation while they were speaking, to have insisted that they do so would have been fatuous.

All in all, the introspection is the valuable part of this set of experiments so far as we have gone with them. Diligent and careful study of the rank lists for the above experiments has failed to show that changes in feeling tone, changes in the feeling with regard to "activity," "passivity," "energy," and the like states can be traced down to the numerical results with any certainty. On the whole, however, the experiments in which the subjects found difficulties of enunciation and the like, produced the longest tappings. Feelings of free activity and pleasurable, "dolce far niente" states usually correlate with lower tapping averages than do other states. The word "activity," however, must not be interpreted to mean a "feeling of work" or "exertion"; often it was hard enough work to recite the combination, but the doing so may have been pleasant or unpleasant, depending upon many factors singly and in a constellation, such as pleasant or unpleasant associations, difficulty or ease of counting the five iambics, and the like; and inasmuch, also, as we have hitherto failed to attempt to "grade" the feelings of pleasure, activity, and the like numerically, correlations of any sort do not show up with

any degree of nicety either way. But the grading of feeling tones is a matter that is on a psychological brink where the footing is horribly slippery; checking up the results would have been necessary, and with this kind of experiments, where the effective phase appears to be so fragile and at the mercy of every other psychological factor, it can hardly be supposed, at least from the results we have already obtained, that to give these experimnets all over again in various orders, would have been either wise or fruitful.

We next take up the matter of general correlations between feeling tone and motor discharge, taking all the pleasant, unpleasant, and neutral experiments in groups by themselves and contrasting the means, mean variations and ranges with one another.

Subject	Pl.	Unp.	Neut.	
A. M.	95.9	92.7	91.7	P U N
M.V.	3.0	3.6	3.1	U N P
Rnj.	15	19	17	U N P
B. M.	88.0	86.1	88.6	N P U
M.V.	3.1	3.6	4.6	N P U
Rnj.	18	17	21	N P U
C. (as above)	107.3	107.4	104.8	U P N
	2.5	2.6	2.7	N U P
	10	11	12	N U P
F.	89.2	89.7	100.1	N U P
	3.2	3.1	3.4	N P U
	17	18	16	U P N
L.	73.8	72.4	74.0	N P U
	3.6	3.7	4.1	N U P
	16	18	20	N U P
N.	86.7	84.8	83.3	P U N
	2.9	2.5	2.7	P N U
	15	11	14	P N U
T.	76.7	——	73.2	P N
	3.4	——	3.6	N P
	18	——	19	N P
W.	95.1	95.2	95.6	N U P
	2.4	2.2	2.5	N P U
	12	10	13	N P U
Y.	50.7	52.3	47.1	U P N
	3.1	4.1	3.2	U N P
	14	18	17	U N P

The difference between these various averages is very slight, and in every case the variations from it are great. But they are usually greater for those which have been obtained while the subjects were in a pleasant state of consciousness than otherwise. Neutrality and unpleasantness appear to work up to a better level in the motor consciousness than does pleasurability; furthermore, introspectively, there are more varied states of pleasure than of unpleasantness; if what the subjects gave introspectively is of any importance, this appears to be empirically substantiated,—they got after a while to be very reticent about the introspecting upon the unpleasant combinations, saying only such things as "very bad," "I do not care for that at all," and the like. But when they got a pleasant combination, they would even wander into forbidden fields of introspection and bring back material which had apparently no connection with the subject in hand. Not all of them, however, but it is quite the fact that the subjects who found most of these combinations pleasant, show up the most negatively in these correlations; at least those who got into the most effervescent states of mind offer those numerical results which are the most recalcitrant to satisfactory correlation.

Hints of a Tonal Calculus

We now turn to the graphs for these experiments. Tiren and Tireen were taken together; and Unrin and Unreen also; these were drawn in pairs to show the differences obtained from those experiments which were the nearest alike. We treated in the same way the graphs for Tira and Thira, and also for Rinaz and Rinad. The remaining nineteen graphs were arranged in groups for similar purposes of comparison.

Comparing Tiren and Tireen, it appeared that the short "e" in Tiren was responsible for the elevation of this graph above the other. Apparently, also, the *"long"* E did not "live up to its privilege," for the graphs were of exactly the same length, even group by group. But the Tiren exceeded the other graph in height only at the beginning and end of its course. Also, the effect of the Tireen was steadier than that of Tiren. The latter showed an average rise toward the fourth iambic and then a

sudden descent. This also holds true in all the groups but the last, as appeared from the long Tiren graph.

A comparison of the next two, Unrin and Unreen, showed less difference in the general motor discharge aroused by these two graphs than was evident in the case of the former two. This might be due to a number of things; first, the difference in the structure of the unaccented syllables in these pairs: -un may determine the motor supply as much as the -rin or the -reen. But the differences in the accented vowels are also to be taken into account, for in the one pair, short "e" and long "e" alternated, while in the other, short "i" alternates with long "e." Hence we have two variables, and not one to deal with.

Rinaz and Thira produced the strongest effects of the Rinaz-Rinad-Thira group and they were nearly equal in height and very similar in form; Rinad and Tira were exactly identical in form, but not so close together as were the other two. Evidently "th" and "z" gave the impetus to the responses, and the open "a" was in each case provocative of restraint in the tapping, for the open "a" experiments took longer time to utter than those which closed with "z" or "d." Rinad was found by the subjects to be a rather poor stimulus, while they attributed to Rinaz a sort of hypnotic or lulling character; yet the graphs show that the latter of these sound-combinations was more arousing than the other. But as a general thing indifferent states were correlated Mean-wise with a greater motor output than were the pleasant. But Rinaz was the more pleasant of these two.

Comparing Niral and Nidal with one another it appeared that the "r" as an initial accented consonant has a greater motor effect than does initial "d." And yet the "d" can be given a much more explosive vocal character than the "r." But the long "i" in Niral must not be forgotten. Nemal showed very well, especially in the fourth group, the insistent character which was attributed to it in the introspection. Comparing the lengths of these graphs does not seem to throw any light on the matter of correlation, for while the long "i" in Niral might be construed as that factor which gives the length to this graph, yet Nerol is

equally long, but Nerol was the first of this series to be given, and perhaps the subjects took longer to say it because it was something new in the way of utterance.

The next group of graphs showed among other things, the various effects of final "l." It is not surprising that Idrel took a longer time to repeat twenty-five times than did Tirel; even the manipulation of the organs of articulation is a more difficult matter for the former combination; time is about the only noticeable difference between the two graphs, their height being about equal. Undol and Unral were also close quantitative equals, but the slightly greater effect of Unral at the beginning of each group, as was seen from a combination graph, allies this effect of "r" with those noted above. It would seem then, that sometimes articulation force (*e.g.* the explosive character of some consonants) is represented in the tapping in an inverse proportional.

Tirel proceeded more evenly across the page than did any other of this group of graphs, but in the final summation graph, Rinel showed that the average stress on each of the twenty-five iambics was exactly the same. Unfortunately such summation graphs were not duplicated to any but the slightest degree in the longer ones and so their significance is doubtful; one point is to be made, however, and that is that where lack of uniformity between the separate groups of the larger graphs is manifest, all that can be stated about the summation graphs as regards one another is just as significant as that which can be stated about the longer graphs.

In regard to the general effect of final "l" in these combinations, one thing is quite remarkable; and that is the frequency with which the fifth iambic of a group ends with a *descent* in the curve. It is exactly fifty per cent: about ten per cent of the time, also, there is no change from the fourth to the fifth foot. The conclusion seems to be that the tendency of final "l" is to produce its greatest motor effect in some other foot than the fifth, when repeated in the manner employed in the above experiments.

The next five graphs cannot be so strictly compared with one another, but if we consider those having long vowels, it appeared that they extended slightly farther to the right than did the others. The longest, "Ritin," seems to offer some sort of positive correlation in regard to the long "i" in the accented syllable, but by comparing it with those which we have hitherto considered, we find that *"length" of vowel is an equivocal expression in reference to the motor consciousness.*

It is proper now to see whether we can deduce anything from the above twenty-seven experiments by combining them in various groups, for many of them contain exactly the same factors in either the accented or the unaccented syllable.

First: arranging these experiments in the order of greatest to least amount of motor discharge called forth in the tapping we get column I. The figures represent 425 tapped strokes (9 subjects, each one tapping 25 times.) Opposite these numbers are the feeling tone judgments of P, U, and N, with the number of times each judgment was made, regardless of which subjects contributed to that particular mass of judgments.

		P	U	N
Idrel	88.4	5	3	1
Tirel	87.4	8	1	0
Tulin	87.0	6	1	2
Nemal	86.8	3	3	3
Rolen	86.8	6	2	1
Ritin	85.8	3	2	4
Thinal	85.4	1	7	1
Niral	85.4	4	4	1
Thira	84.8	4	3	2
Rinaz	84.8	8	1	0
Aren	84.6	5	1	3
Undol	84.4	7	1	1
Unral	84.4	3	3	3
Rineen	84.0	4	5	0
Unrin	83.6	2	3	4
Nerol	83.6	7	0	2
Tiren	83.6	5	3	1
Unreen	83.4	4	4	1
Ridev	83.2	2	5	2
Rinel	83.0	5	2	2
Rinad	82.8	3	3	3
Nirees	82.8	7	2	0
Nidal	82.4	5	2	2
Tireen	82.0	6	2	1
Tira	81.8	5	1	3
Nilur	81.6	2	5	2
Rileet	80.8	8	1	0

If, now, one arranges these same experiments in two columns, one indicating a decline in the amount of motor discharge, and the other a descent in pleasurability, it can be seen how far, generally speaking, these two factors are correlative. Likewise, taking the motor decline once more and pairing it with another list indicating the decrease in unpleasantness for the same experiments, another set of correlations can be obtained. We have determined the pleasurability and unpleasurability on the following basis: where under the P column or the U column we find the same numbers, *e.g.* $\begin{matrix}\mathrm{P} & \mathrm{U} & \mathrm{N}\\ 5 & 2 & 2\end{matrix}$ and $\begin{matrix}\mathrm{P} & \mathrm{U} & \mathrm{N}\\ 5 & 3 & 1\end{matrix}$, we have called the first of these the more pleasant, and the second the more unpleasant; where we find the following situation $\begin{matrix}\mathrm{P} & \mathrm{U} & \mathrm{N}\\ 6 & 1 & 2\end{matrix}$ $\begin{matrix}\mathrm{P} & \mathrm{U} & \mathrm{N}\\ 7 & 1 & 1\end{matrix}$, we have called the second of them the more unpleasant. Here, as in the former experiments upon the simple vowels and consonants, we find that pleasantness and amount of motor discharge are inversely correlated. The average divergence of the position of terms in each column is about ten points away from a one to one correspondence. We now come to another interesting phenomenon. Taking those experiments which are nearest alike, and computing from their difference the effect of one vowel over another, or one consonant over another in the motor consciousness, we can draw the following tentative conclusions. To begin with pairs of experiments:

Exp.	M.D.	P	U	N
Thira	84.8	4	3	2
Tira	81.8	5	1	3

Here the unaccented "Th" has a greater motor effect than does "T." Also the feeling tone correlation is strong for the increased motor effect of the unpleasant. Take another:

Exp.	M.D.	P	U	N
Unrin	83.6	2	3	4
Unreen	83.4	4	4	1

Here short "i" accented has a greater motor effect than does long "i"; and the same feeling tone correlation also holds true as with the above.

Again,

Exp.	M.D.	P	U	N
Tiren	83.6	5	3	1
Tireen	82.0	6	2	1

In this pair the short vowel may be credited with the greater motor effect.

And in

Exp.	M.D.	P	U	N
Rinaz	84.8	8	1	0
Rinad	82.8	3	3	3

We find the accented find "z" as that element which gives the greater motor effect. But in both of the above, feeling tone inferences are dubious. Let us now compare several groups:

Exp.	M.D.	P	U	N
Ri-tin	85.8	3	2	4
Ri-naz	84.8	8	1	0
Ri-neen	84.0	4	5	0
Ri-dev	83.2	2	5	2
Ri-nel	83.0	5	2	2
Ri-nad	82.8	3	3	3
Ri-leet	80.8	8	1	0

Here the long accented vowels seem to have the advantage, and the "naz" and "nad" do not contradict the deductions about them made immediately before.

Exp.	M.D.	P	U	N
Ti-rel	87.4	8	1	0
Ti-ren	83.6	5	3	1
Ti-reen	82.0	4	4	1
Ti-ra	81.8	5	1	3

Here the short vowels again produce, or assist in producing, the greater motor effect. Deductions on the basis of feeling tone are hardly possible in either of these two groups. We make two more comparisons:

Exp.	M.D.	P	U	N
Ni-rees	82.8	7	2	0
Ni-dal	82.4	5	2	2
Ni-lur	81.6	2	5	2

Here the feeling tone enters again as an apparent factor, but rather contradictorily to what has been deduced from the experiments as a whole.

Exp.	M.D.	P	U	N
Un-ral	84.4	3	3	3
Un-dol	84.4	7	1	1
Un-rin	83.6	2	3	4
Un-reen	83.4	4	4	1

Which completes our groups of this kind.

In connection with the next matter, a few symbols are necessary. Let K1 = the accented consonant which stands immediately before the accented vowel, thus: ni-*R*al, un-*D*ol, etc. Let also K2 = that accented consonant standing immediately after the accented vowel, or which closes the accented syllable,

thus: ni-ra*L*, ri-ni*Z*, etc. Let also V stand for the accented vowel, and let the letters i, e, a, etc., represent the short vowels, and the letters I, E, A, etc., represent the long vowels. Let also the symbol > stand for the "greater than" and the symbol < stand for "less than." Then, in general, taking all the commonly used accented final and initial consonants of the accented syllables, we have:

$$\begin{aligned} K2L &> K2N = 17.4 > 15.5 \\ Ve &> VE = 17.3 > 12.0 \\ Va &> VA = 17.5 > 12.8 \end{aligned}$$

and $K1L > K1R > K1N = 17.0 > 14.0 > 13.6$,

so that the motor effect of K1N < the motor effect of K1R and also < that of K1L. We can say, then, that of the consonants, K1L and K2L have the greatest motor effect, and the short vowels also, in general, rank with them. This is significant, and shall be used later in the correlation of large masses of sounds.

3. TRANSMOGRIFICATIONS OF ENGLISH POETRY

This part of the work includes several kinds of experiments. According to the plan outlined in the early paragraphs, we are now to consider the effect of more complicated collocations of the speech elements than have been hitherto employed. The poets themselves are experimented upon from now on, and in a twofold manner: first, by casting into decasyllabic lines the sounds as they appear in the tabulations of frequency, and then by employing both single lines and ten-line passages from poetry to show the various effects of combination with and without meaning.

The Effect of Meaningless Single Lines from the Tables of Sound Frequency

We now turn to the first of these experiments. They were devised to show the psycho-motor effect of those sounds which certain poets use most frequently as well as those which they use less frequently, and in each case they attempted to illustrate the proportion of use by the frequency of repetition in the

decasyllabic line into which they were arranged. Taking four of the poets from the tables of sound frequency hitherto mentioned, we find them using the sounds of the language in the following proportions. We take only the first twenty or more sounds from each one, accented and unaccented alike. (Short vowels, small letters; long ones, large.)

	Keats		Byron		Tennyson		Arnold	
Acc.	Unacc.	Acc.	Unacc.	Acc.	Unacc.	Acc.	Unacc.	
R	3.9 u	5.3 :R	5.3 u	5.3 :R	5.0 u	5.3 :R	5.5 u	4.0
N	3.7 i	4.1 :N	4.0 N	4.5 :L	4.5 i	4.0 :N	4.6 i	3.4
L	3.5 N	3.5 :L	3.5 i	3.4 :T	3.1 N	3.2 :L	3.6 N	3.0
S	3.4 R	3.1 :E	2.9 R	2.7 :M	2.7 :Th	2.9 :T	3.3 a	2.9
T	3.1 T	2.3 :D	2.5 T	3.1 :S	2.6 R	2.8 :S	3.1 D	2.6
D	2.5 S	2.0 :M	2.4 Th	2.3 :E	2.5 D	2.1 :E	2.3 Th	2.5
e	2.1 Th	1.9 :S	2.4 e	1.7 :a	2.3 a	1.8 :A	2.2 L	2.1
V	2.0 e	1.7 :T	2.2 Z	1.7 :I	2.1 L	1.8 :D	2.2 Z	1.8
u	1.9 O	1.7 :O	2.1 O	1.6 :D	2.0 Z	1.8 :O	2.1 R	1.7
E	1.8 L	1.6 :A	1.8 D	1.6 :N	2.0 T	1.8 :F	2.1 E	1.7
P	1.7 a	1.5 :u	1.8 a	1.5 :Z	1.9 Th*	1.6 :I	2.0 T	1.6
M	1.9 D	1.5 :I	1.6 I	1.4 :P	1.9 Ng	1.0 :M	1.8 e	1.4
A	1.7 K	1.4 :e	1.5 E	1.4 :i	1.8 W	1.0 :o	1.5 H	1.4
F	1.7 Ng	1.1 :a	1.4 Th*	1.3 :B	1.7 E	.9 :e	1.4 Th*	1.3
i	1.6 Th*	1.1 :i	1.4 o	1.2 :o	1.6 I	.9 :K	1.4 W	1.3
K	1.6 M	1.0 :P	1.4 L	1.2 :F	1.4 e	.8 :W	1.3 S	1.1
H	1.4 W	1.0 :K	1.2 S	1.0 :W	1.4 e	.7 :Z	1.3 B	1.0
I	1.3 E	.9 :o	1.1 M	.9 :u	1.3 O	.7 :i	1.2 A	.9
O	1.3 F	.8 :F	1.1 W	.8 :K	1.3 H	.7 :u	1.2 K	.7
W	1.2 V	.8 :V	1.3 B	.8 :e	1.2 OO	.6 :a	1.0 Ng	.7
Z	1.2 Z	.7 :Th	1.1 P	.8 :O	1.2 K	.6 :B	1.0	
				:G	1.2 St	.6 :P	1.0	
						:St	1.0	

* Surd.

All but one of these poets, Byron, employs his sounds approximately in the ratio of ten accented to eight unaccented ones. Byron uses nine unaccented ones to every ten accented ones. We took the first seven accented consonants and the first three accented vowels, and the first five unaccented consonants and the first three unaccented vowels from the other three poets; in Byron's case the same number of accented sounds were used, but six unaccented consonants and three unaccented vowels were taken to make his 10:9 proportion. Taking then, ten accented sounds from each of these poets, and the proportionate number of unaccented sounds, and arranging them in a line of five iambics with the

most used sounds in the more prominent places in the line, namely the first and the last feet, we obtain the following four experiments:

Keats: Nĭ rŭl sŭ vēēd rĭ nĕst ĭt ĕl ĭth rēēn.
Byron: Zŭ rēēn tĭth nōle dĕr tŭll thĭn sōde tŭ rēēm.
Tennyson: Thŭ răl dĭ rēēt thŭ nīme ră dēēs ŭn tăl.
Arnold: Thŭ rēēn dĭn lāse ză fōde nĭl tāne thŭ lēēr.

The 10:8 and the 10:9 proportions are fairly well kept in these combinations, as can be proven by counting the sounds. The arrangement of sounds is quite arbitrary, but in making such a combination, there are many things to be considered besides mere proportion. For example, one must test by means of his ear what combinations are suitable to follow one another; and when strict proportion cannot be followed, one must be judicious.

If, now, we take the next ten accented sounds in the lists, and combine with them the proper number of the next eight or nine unaccented sounds, we have the following experiments for these poets:

Keats: Lă māz mō kĭf dē pōth lă pām wē hō.
Byron: Dō thăv lō pī sē kĕ dă thĭp lī vā.
Tennyson: Tē pŏz lĭ bĭn ĕng wō zīte nŭf wē nŏp.
Arnold: Rē mŏz ĕt wĭk sā thŭ wē zĕm hē mī.

(It must be noticed that when the appearance of the list indicates that more than three vowels to seven consonants are the materials out of which the experiment would normally be made, we have followed the list, rather than discarded the prominent elements in it.)

These experiments were presented in pairs: first the two representing Keats, and after that the others in the order in which they occur above, finishing each poet as we proceeded. Each line was tapped and recited five times. The instructions were to read the line over until it became easy to read; but not to wait until associations came up; then the tapping and reciting went on as it had done before, the instructions again being to

"tap at each accented syllable." A few of the subjects practised reading the lines over once silently and tapping at the same time, in order that full preparation for the experiment would not be lacking. The idea was to get the full effect of the line *while tapping*, in order that the motor manifestations could be called representative in the fullest sense of the word. The introspection which they gave for these experiments follows:

Keats I. (The first ten accented and the first eight unaccented sounds.)

Visual imagery of maples and other deciduous trees in the fall of the year; the air is frosty and the whole scene is grayish; very objective.

The rhythm feels like dance music; very contagious; thought of evening bells; very romantic. Gentle thing; not much action to it; a little Spencerian; deals with pastoral things.

Keats II. (The second group of Keats' most used sounds.)

Visual and auditory imagery of the surf; also of fields; sounds go well together. Seems short and broken up; compares it to an "Italian" salad. Brings imagery of the sea; thinks of something like the "Ancient Mariner." Not very active.

Byron I.

Something superficial about it; kinaesthetic and visual imagery of idly following things about. Minor, meditative and solemn; attributes this to the long vowels; thinks of something like "Crossing the Bar." An epic, recounting adventures. Deep and funereal.

Byron II.

Active thing; relates to strength and power and brawny arms. Sounded like the speech of a big-chested, half-civilized people living in a cold climate. Rather dramatic and superficial.

Tennyson I.

Inactive; sad throughout; subjective thing. Evokes pity and compassion; elegiac thing; sorrow, not wild, but quiet and domestic implied. Very rhythmic; gives a feeling of solemnity felt in the midst of happy surroundings. Images of a quiet, restful woodland scene. Asked if it was Tennyson. Just a little dramatic; not quite sincere. A little tragic and sorrowful; thinks of Fate.

Tennyson II.

Rhythmical and dramatic; sounds Shakesperean. Kinaesthetic imagery of many motions in different directions. Makes him short of breath; thinks of dying gladiators; mentioned "Heldenleben." An explanation in some dialect of an unfortunate event.

Arnold I.

Something strong and military about it. Rhythmic, but not very deep. Medieval and romantic; seems to be a description. Thinks of the "Meister-singers"; active and objective.

Arnold II.

Unpleasant taste images aroused; something psycho-pathic about it. Interesting, but not emotional; full of irritating things; more like conversation than anything else. Leaves one a little gasping; sounds like some one timidly trying to recite.

It must be remembered that these combinations were presented to the subjects without their knowing what poets they represented; nor was it a guessing contest, either; no stress was laid upon anything but a good reading of the lines.

There follows the correlation between feeling tone and motor discharge, in general, for all the subjects in the above experiments.

Subject				
A. M.	94.3	91.0	104.9	N P U
M.V.	2.1	2.0	3.4	N P U
Rnj.	10	12	16	N U P
B. (as above)	74.0	——	72.2	P N
	3.4	——	3.6	N P
	15	——	17	N P
C. " "	92.5	——	82.0	P N
	3.6	——	5.5	N P
	19	——	27	N P
F. " "	73.5	75.7	——	U P
	3.6	3.8	——	U P
	17	18	——	U P
L. " "	72.0	74.8	——	U P
	3.2	2.7	——	P U
	18	15	——	P U
N. " "	85.2	84.6	——	P U
	2.4	2.0	——	P U
	12	11	——	P U
T. " "	75.3	77.4	——	U P
	3.0	3.7	——	U P
	20	13	——	P U
W. " "	87.8	85.9	91.2	N P U
	2.3	2.5	2.4	U N P
	10	13	12	U N P
Y. " "	39.9	41.9	52.0	N U P
	2.3	3.2	3.0	U N P
	15	17	19	N U P

Comparing these results with all similar correlations, we find that none of the subjects have remained constant during the experiments, as is evidenced by the following. A.'s longest tappings were twice for the pleasant, twice for the unpleasant and twice for the neutral. B.'s were three times for the pleasant, twice for the unpleasant, and once for the neutral, etc. The whole list is given below.

A.	P 2	U 2	N 2	
B.	P 3	U 1	N 2	
C.	P 1	U 2	N 2	(this subject did not begin with the others)
F.	P 3	U 1	N 2	
L.	P 0	U 3	N 3	
N.	P 3	U 1	N 1	(only one kind of judgment was made in one series)
T.	P 4	U 2	N 0	
W.	P 2	U 1	N 2	(only one kind of judgment was made in one series)
Y.	P 1	U 1	N 1	(this subject did not begin with the others, and in one series made only one kind of judgments)
	19	14	15	

Comparing the M.V. and the Rnj. in a similar manner gives equally varied results.

Let us now consider the graphs for these experiments. Their resemblances were more striking than their differences, and it is not unlikely that the reverberations set up in the motor consciousness just by this new material were too strong to be altered by the other factors involved. In the first place it was found that these experiments produced a much lower motor output than did those preceding them; Idrel had reached a height of 88.4 mm.; none of these reach anything above 78.8 mm. (the Arnold II). Massing together the P, U, and N judgments, and correlating them with the amounts of motor discharge as shown by these graphs, we obtain:

		P	U	N
Arnold II.	M.D. av. 78.8 mm.	3	4	2
Tennyson I.	78.6	7	1	1
Byron II.	78.4	8	0	1
Tennyson II.	78.0	4	4	1
Arnold I.	77.6	4	4	1
Byron I.	77.4	5	4	0
Keats II.	77.2	7	1	1
Keats I.	76.6	7	1	1

This comparison would seem to indicate that the most pleasant experiments go with the strongest *and* the weakest tappings,

while the most unpleasant tend to produce those which are midway between the greatest and the least. No correlation with the feelings of activity adds anything to what we have already observed, that sometimes, and sometimes only, the feeling of ease means longer finger strokes, and feelings of inhibition and difficulty mean shorter strokes.

None of the experiments numbered III are given for any of the poets, and hereafter only No. I of the first three is presented, because it represents better than do the others the differences in sound frequency for the poet. No. III, however, was constructed by combining half of the first and half of the second of the above groups of sounds, Nos. I and II, to illustrate the poet's use of those elements which are not either very frequent nor infrequent, and thus we had a set of three experiments which began with the liquids, and ended with the gutterals and fricatives.

Experiments numbered IV, V, and VI in the case of each poet are transmogrifications of single lines of poetry; experiments VII, VIII, and IX are lines of poetry rearranged, keeping the accented words of the original accented, and the unaccented words unaccented. Experiments X, XI, and XII are lines of poetry, "clothed and in their right mind," and for each of the twenty poets experimented upon there are these twelve experiments, which start with the tonal elements, pass through the nonsense verse of transmogrification, through also the ungrammatical poetry into the normal meaningful lines from which all had been ultimately derived that preceded them. Thus we had 240 experiments upon the poets arranged in such a way as to supply sufficient data for a compact thesis in itself. In the case of nine of the twenty poets, the same material entered into the transmogrifications, rearrangements and the meaningful lines, so that Experiments IV, V, and VI were the transmogrifications of the material in Experiments X, XI and XII respectively, and Experiments VII, VIII and IX were the rearrangements of the same material as had been used in the others. In the other eleven poets, which were experimented upon first,

only now and then was such a symmetrical arrangement carried out. We decided upon the method of repeating the same sounds in three different relations in order to exactly determine what both grammar and meaning had to do with the effects of the poetic line upon the motor and the introspective consciousness. But only in the case of four of the poets do we give the experiments from IV to XII. What has been omitted will be considered in later, summarizing paragraphs.

It was the purpose at first to obtain experimental material from the poets which would duplicate in tonal quality Experiments I, II, and III; after a futile search for such lines, it was given up; too many extraneous elements entered into the matter. In the first place, very few lines of the poet actually follow the tonal pattern of the first experiment in our series, and those that do, usually contain inverted iambics, if they contain iambics at all; in the second place, to find decasyllabic lines that are regularly accented in the iambic pattern is not always possible, and when such are found, they are likely to be some of the poorest lines, esthetically considered, that the poet suffered to leave his pen. So that in every case almost, Experiments I, II, and III are in a class by themselves, and the other nine experiments of the series are in another class.

The Transmogrification of Single Lines of Poetry

The business of transmogrifying single lines of poetry is quite difficult, for the restrictions placed upon one in this work are very rigid,—words must not be made, and sounds must not be left out; again, to avoid making words, one may have to construct a very badly sounding line, and sacrifice to the purpose of the experiment much of his artistic predilection for the beauty of tones; let any one who doubts the difficulty of the matter attempt the task, and he will find that we have but lightly touched on the obstacles to be encountered. The transmogrifications we have used in this experiment are but a fifth of the number which we attempted to complete with satisfaction to ourselves.

These experiments were presented in the order in which they are given in the following pages. The first four poets experi-

mented upon were Byron, Keats, Arnold and Tennyson, and the forty-eight experiments upon them were well under way before the I and E Experiments had been completed. This was a relief to the subjects, who rather chafed at the idea of having so many similar combinations week after week.

There were fifteen experiments performed on Keats, but we have omitted all but twelve in our consideration, because we discovered that the others were of no importance for the work in hand. Our original plan had been to experiment upon very many more than twelve decasyllabic lines for each poet, but time did not allow, and this had to be given up. Neither were the subjects able to react to twenty experiments an hour as well as to twelve.

The introspection for the Keats and Byron experiments is very interesting indeed, from the very start, and the transmogrification of the famous line from Byron's "Apostrophe to the Ocean" was a decided success, but it is not beyond cavil that the line may have contained too many hints at the sense of the original verse.

After the introspective account of the matter, we have given the numerical results which we shall consider at once.

Keats IV. Wŏn fĕmz ē nānj ŏv dī năl tĕr ĕn tēēv.,* transmogrified from "One faint, eternal eventide of gems."

Nothing in the introspection compared to the original meaning or mood of the line.

Keats V. Tōō zowb ĭth bīnd thă räwl mĕ tĭng wĭn tī. From "To bind them all about with tiny rings." Introspection.

Visual imagery of a farm; auditory imagery of some bells ringing. Sounds like an ode; vocal placement seemed forward in the mouth. Gives a light and cool effect; the sounds vary in pitch very much; more resonant than the former one.

* From now on the diacritical marks will have their usual significance over single vowels; but when two vowels occur together, the following interpretation is required: ēē = ē; ŏŏ = the oo in "brook"; ōō = the oo in "food", etc; a as in "ask" is indicated by no mark at all; in addition to this, the ow, aw, ou, oi, and other diphthongal sounds are pronounced as usual in English. Differences between the sonant and surd th, are not indicated here, though they were in the experiment.

Keats VI. A thûrn ŭs tōō thŭ bow tōō flăndry bīde. From "A flow'ry band to bind us to the earth."

Very rhythmic line; Chaucer's poetry came to mind. Imagery of a high tower; romantic scene, maybe some battle being narrated; romantic and idyllic. "Flaundry" a strange word; thinks of "Flanders" and "laundry" at the same time.

Keats. Experiment VII. So cooling very still was and the air. From "The air was cooling and so very still."

Imagery of the twilight. Visual imagery of a bright green color. Cool sensation in the mouth. Very conscious of lips.

Keats VIII. The dwindled of its trace and edgings brim. From "The trace and dwindled edgings of its brim."

Imagery of snow; "trace" a "cold" word. Feels lips to be very active.

Keats IX. Across the move would blue a little cloud. From "A little cloud would move across the blue."

Gives an inane feeling; "move" and "blue" are "sticky" words; "cloud" doesn't go with them. Cannot say "little cloud" fast enough to suit the line. The word "across" is too hard; the "k" sound sticks. Lips rather prominent in consciousness.

Keats X. A bower quiet for us and a sleep.

Odd that the gutteral should have been used,—"quiet." "Bower" the only "quiet" sound. Uses too much breath for the meaning.

Keats XI. "With lucent syrops tinct with cinnamon."

Thinks of toddy and cordials; just the opposite kind of a scene came up. Much taste imagery; visual imagery in bright colors. The line hisses too much; imagery of peppermint. Tickles the tongue.

Keats XII. "That broodest o'er the troubled sea of mind."

Mind in a quiet uncertainty. Thought of Byron, and Hamlet; visualized a cliff. Feeling of a cosmic melancholy. Gives a gentle melancholy; "mind" too abrupt.

Byron IV. Shŭn dōle ow rŏd thū närk blōre ō lănd ēēp. From "Roll on thou dark and deep blue ocean, roll."

Visual imagery of some one on a rock by the sea; sounded like a foreign language. Subject A.—Imagery of the ocean, in a storm; the jerky effect here is justifiable. B.—Imagery of a ship on the ocean in stormy weather; seemed to take more force. D.—Imagery of the sea; heavy waves; dark colors. F.—Sea imagery; "nark" is very hard. "Blore o" is the blowing of a horn. K.—Great deal of resonance; no imagery. L.—Sea concepts aroused; thinks of Norsemen, etc.; very thrilling. M.—Feels the roar of the ocean; visual imagery very rich. P.—Counting bothered a little; imagery of Hol-

land. S.—Mixture of Persian, Arabic and Hindustani language; great deal of imagery of the ocean; sounds fill the mouth.

Byron V. Thŭ vī lănd sā nĭl jī tā frō the vēē. From "The inviolate island of the sage and free" (with two unaccented syllables omitted).

Narrative poetry; thinks of natural scenes. A gesture could do it all better than words. Imagery of gaudy colors; not smooth sounds. Not very smooth; especially the fourth iambic; imagery of a pastoral scene. Imagery of some big man saying this in a thunderous voice. Lip sensations unpleasant.

Byron VI. Hăs mowd stĭ rīne whā stĕsh ră mĭd thŭ krāthe. From "Amidst this wreck where thou hast made a shrine."

Describing a very interesting place; something troubled and dolorous about it. Implies a rough activity. All the sounds very unpleasant; do not fuse. Too staccato; but "su krath" very good. Just a strange, incomprehensible language.

Byron VII. "With stirred as rose her dream leaves with the air." From "Stirred with her dream as rose leaves with the air."

Ethereal quality about the sounds. Rhythmic; thought of a sleeping girl. The words "air" and "stirred' the best of all; olfactory imagery.

Byron VIII. At bluelit moon and midnight on the deep. From "At midnight on the blue and moonlit deep."

Imagery of a ship at midnight; pleasant self-feelings. Smooth, soft, and gentle combination.

Byron IX. Upon beheld decline who hath my brow. From "Who hath beheld decline upon my brow."

Thinks of a pessimistic old man. Monotonous; takes too much breath. Thinks of some unsuccessful person.

Byron X. "And temple more divinely desolate."

"Emp" sounds pointed. "Desolate" just suits the meaning; it's a cold, blue word; "divinely" doesn't have anything to do with the line. The "hiss" in "desolate" very expressive.

Byron XI. "Yet I was born where men are proud to be."

Prosaic and pessimistic; sounds very resonant. Very strong physical sensations. "Yet" always a vocal surprise.

Byron XII. "And silent rows the songless gondolier."

Very dark and somber feeling induced. "Silent" the only silent word in the line; "gon" in "gondolier" is too gutteral. Cheerful and lively line in spite of the intended meaning; "songless gondolier" a tonal equivocation.

The remarkable thing about the graphs representing these twelve experiments upon Byron and Keats was that in nearly every case the motor discharge for the Byron Experiments is greater than that for Keats, and the final averages showed that the combined finger movements for the Byron experiments were eighteen metres longer than they were for Keats. But we must not be too sanguine; the tonal elements in Byron are not the ones which have hitherto been those arousing the strongest reactions, and the fact that Keats was experimented upon first may indicate that we have only practise curves before us in this instance. But there was something rousing and enthusing in all the Byron experiments which the subjects did not find in those on Keats, which may account for the matter more exactly. The character of the lines transmogrified and employed in other ways is very different for the two poets, as any one can see from a glance at the material; but whatever may be the nature of the individual sounds used in the above experiments, we find here that order and arrangement are potent factors, and single decasyllabic lines may produce different effects than do larger passages. One could also notice in these graphs the form quality of the decasyllabic groups,—the regular thing in a rhythmic line is for the first and the last feet to demand more motor discharge than the intermediate iambics. And the form-quality of the Byron lines always differed from those of Keats. Again, the mean variation of the tappings for the meaningful lines is less, according to the graphs, than it is in the first six of the experiments for these poets.

Every one will admit that Byron is a more oratorical poet than Keats, and that there is a power and vigor to Byron's poetry which is not found in any other English poet. It would seem that the temperamental character of the poet had gotten into these experiments, and that also the quieter and more pastoral nature of Keats had not been omitted from the experiments which we graphed with those of Byron. It is admitted that the experiments were made with the different poets in mind, and that even the first three experiments were patterned upon what was

conceived to be the poet's tonal characteristics, but the results are what they are, and whether from one cause or another, they show that the experiments on Byron called for the more activity on the part of the motor consciousness. This is enough.

The next experiments to be considered and compared are those on Arnold and Tennyson.

Arnold IV. Nōr hī bŭt smōrd hĭz nēērd ŭkt lŏd ōrn wābez. From "But he looked on, nor smiled, nor bared his sword."

Thinks of a battle; (but "smord" never meant "sword" consciously). "Smord" and "neerd" indicate the presence of trouble.

Arnold V. Lō mōrdz ŭm stûr dīle hŭs kĕr mīze hĭz māfe. From "Like some old miser Rustum hoards his fame."

Tragic narrative poetry.
"Hus" the highest tone in the line.
"Mafe" not very pleasant; the auditory consciousness much more pleasant than the reading consciousness.

Arnold VI. Zĭ nōld bē krĕm ĕs lāj ē rŭld shō hīze. From "'Behold,' she cries, 'so many rages lulled.'"

"Z" the prominent consonant.
"Kremlin" aroused by "krem."
Seemed to be a "begging symphony" of the Mohammedan beggars.

Arnold VII. As she her echo stormy screams sails by. From "Echo her stormy scream as she sails by."

"S" the right sound for this meaning.
Imagery of excited movement.
The "s" sounds are very unpleasant; sounds like a poorly oiled wheel.
"Sails" too heavy a word for an unaccented syllable.

Arnold VIII. All who pained desert lion some of day. From "Of some pain'd desert lion who all day."

Hard to say "pained" in the time allowed.
The words "some" and "desert" disturbed the rhythm.

Arnold IX. Her it the glass lake flying over shall. From "Shall the lake glass her, flying over it."

Sounds very pleasant; gives a "thin," damp feeling.
Lips much in consciousness.
Mood aroused akin to that of Wordsworth's Lucy poems.

Arnold X. "The sails that gleam a moment and are gone."

"Can this be the same poet as the last nine experiments illustrated?"
Liked the sense but not the sounds or rhythm.

Arnold XI. "Before this strange disease of modern life."

Sounds unpleasant per se; "s" too frequent.

"Strange," very unpleasant and nasal; the "ern" of modern also a bad sound.

Arnold XII. "He lies in death upon the common sand."

"Death" as a sound is very pleasant here; one cannot expand while saying it.

The words "common sand" go too quickly for the meaning.

Tennyson IV. Fōr thāri̋ng kĕrn hē tŏft ă sēēfly thīle. From "He therefore, turning softly like a thief."

Thinks of the ocean and the surf; "a cynical line."

Means something soft, quiet, and subdued; "kern" is a lovely word.

The letter "k," while dissonant, only brings out the harmony of the other sounds the more.

Tennyson V. A whĭl ĭn dŏst ûr gĕnward nĭspērs ēēp. From "Again in deeper inward whispers 'lost'."

Thinks of a soft, subdued scene; evening.

Thinks of whirling dust; whispers; deep; etc.

Thinks of Gray's Elegy.

Tennyson VI. Whār lämz tōō ûrkĭng wīle tōō bĭsk ăn vōrn. From "Scorning an alms to work whereby to live."

"Vorn" is Scandanavian; thinks of the early Britons.

"Lamz" = "lambs," but they were not frisky; something dark and wearisome about the line.

"Urk" brings a dead stop.

Sounds like Matthew Arnold; "urk" a little hard.

Very personal, and sad; gloomy melancholy; fatalistic.

Implies a moral situation.

Tennyson VII. But will made fate in weak by time and strong. From "Made weak by time and fate but strong in will."

Uninteresting, abstract, philosophical.

The sounds too short for the meaning.

The sense takes away the pleasure of the sounds.

Tennyson VIII. Now crimson sleeps the now the petal white. From "Now sleeps the crimson petal, now the white."

Imagery of carnations, visual and olfactory.

"Crimson" visualized as "pink."

The sounds are good even without meaning.

The sounds of the word "petal" are too light for the rest of the line.

"Crimson" the best sound of all; thinks of English pudding.

Tennyson IX. To scorning live whereby an alms to work. From "Scorning an alms to work whereby to live."

Stupid sort of a line; "scorning" a dreadfully "hard" word.

Laborious combination; has internal bodily strains.
Didn't feel that the tapping was at all expressive.

Tennyson X. "And on the mere the wailing died away."

Rather onomatopoetic; but "died" has a little too much movement about it.
Tried to be sad, but did not succeed.

Tennyson XI. "The silent water slipping from the hills."

The word "silent" means distance and seclusion.
"Sliding" would have been better than "slipping" for onomatopoeia; the short "i" is too full of impact.
Too much sound for the sense.
Sounds slightly artificial and banal.
"Slipping" is most annoying; gets no motion out of the line.

Tennyson XII. "And all the coverlid was cloth of gold."

"Coverlid" strangely pleasant for a "k" sound.
Nasal; "clóth of gold" pleasant to say; *but got visual imagery of a scarlet cloth.*
"Gold" the conspicuous word.
Mouth seems very open in the last two feet.
"Lid" doesn't fit in.
Something "insincere" about it.

As typical of the numerical results obtained from the experiments numbered I to XII, we present those for Tennyson. First a table showing the results from the mean of the tappings for each subject arranged both according to feeling-tone and also to the triadic grouping of the experiments as outlined above. In the first column stand the abbreviations for the names of the subjects, and in the last column the averages of the tappings for the pleasant, unpleasant and neutral experiments, regardless of group.

The next table presents the same results quâ mean variation. And the third table shows the rank lists which exhibit the acme of the steadiness attained in this whole group of 240 experiments. The mean alone appears to be significant in point of comparison with the general psycho-motor correlations hitherto obtained.

TENNYSON, EXPERIMENTS I-XII. MEAN

Subject	I-III	IV-VI	VII-IX	X-XII	Av.
A. P.	86.3	81.6	87.4	90.0	86.3
U.	——	87.6	89.6	87.7	88.3
N.	——	——	93.5	——	93.5
B. P.	75.8	78.5	——	78.8	77.7
U.	80.1	75.8	79.1	——	78.3
N.	83.8	——	——	——	83.8

C. P.	91.8	87.9	83.5	76.6	84.9
U.	—	—	87.3	—	87.3
N.	—	87.9	—	—	87.9
D. P.	103.8	104.4	102.6	106.1	104.2
U.	98.8	—	96.0	97.9	97.6
N.	—	—	96.8	—	96.8
F. P.	82.0	79.9	83.0	80.5	81.4
U.	77.2	73.0	79.6	—	76.6
N.	—	—	77.0	80.8	78.9
K. P.	56.1	47.9	—	50.8	51.6
U.	—	—	47.4	49.1	48.2
N.	—	—	52.4	—	52.4
L. P.	69.3	67.3	77.1	78.5	73.1
U.	70.2	—	80.9	83.5	78.2
N.	—	—	69.0	—	69.0
M. P.	85.0	87.8	—	—	86.4
U.	85.2	80.1	90.6	85.7	85.4
N.	—	85.7	—	88.8	87.2
P. P.	127.0	131.2	131.7	134.1	131.0
U.	127.9	—	—	—	127.9
N.	—	132.4	—	—	132.4
S. P.	—	113.5	111.3	111.2	112.0
U.	115.6	—	—	—	115.6
N.	—	—	—	—	—

TENNYSON, EXPERIMENTS I-XII. M.V.

Subject	I-III	IV-VI	VII-IX	X-XII	Av.
A. P.	3.7	2.3	4.7	3.8	3.6
U.	—	4.1	3.3	3.9	3.9
N.	—	—	3.4	—	3.4
B. P.	3.9	4.3	—	4.4	4.2
U.	7.1	4.4	5.8	—	5.7
N.	4.5	—	—	—	4.5
C. P.	4.0	4.7	4.6	4.2	4.3
U.	—	—	7.1	—	7.1
N.	—	3.8	—	—	3.8
D. P.	3.8	1.7	1.4	2.0	2.2
U.	3.2	—	4.6	2.8	3.5
N.	—	—	5.6	5.6	5.6
F. P.	4.5	6.0	5.4	4.6	5.1
U.	3.7	4.5	6.1	—	4.7
N.	—	—	4.3	7.2	5.7
K. P.	6.2	5.3	—	6.0	5.8
U.	—	—	6.2	5.5	5.9
N.	—	—	5.7	—	5.7

L. P.	5.1	4.1	4.8	3.7	4.4
U.	3.4	—	3.7	3.6	3.6
N.	—	—	5.1	—	5.1
M. P.	2.4	5.0	—	—	3.7
U.	3.9	4.8	3.3	5.4	4.3
N.	—	4.1	—	4.1	4.1
P. P.	1.7	2.0	1.6	2.0	1.8
U.	2.4	—	—	—	2.4
N.	—	2.6	—	—	2.6
S. P.	—	2.0	3.1	2.6	2.6
U.	—	—	—	—	—
N.	2.8	—	—	—	2.8

TENNYSON. RANK LISTS. EXPERIMENTS I-XII.

Mean

Subject												
A.	e	g	f	d	e	g	g	f	f	g	g	g
B.	c	d	c	e	d	d	c	d	b	f	d	b
C.	g	f	g	g	f	f	e	e	e	d	b	c
D.	h	(throughout)										
F.	d	c	d	f	c	c	d	b	d	b	e	e
K.	a	(throughout)										
L.	b	(throughout)										
M.	f	f	e	c	g	c	f	g	g	e	f	f
P.	j	(throughout)										
S.	i	(throughout)										

MV.

A.	d	f	e	g	c	e	b	g	e	f	d	h
B.	h	i	g	e	g	f	e	j	h	j	f	d
C.	b	h	j	f	h	d	j	b	d	d	g	i
D.	e	c	d	a	a	a	i	a	f	a	a	c
F.	g	g	f	j	j	g	h	f	i	h	i	g
K.	j	j	i	h	i	j	f	i	j	e	j	j
L.	i	d	h	d	c	i	g	e	g	g	e	e
M.	f	e	b	i	f	h	c	c	c	i	h	f
P.	a	a	a	c	d	b	a	b	a	b	b	a
S.	c	b	c	b	b	c	d	d	b	c	c	b

Rnj.

A.	e	g	g	d	b	f	b	f	d	i	d	i
B.	f	j	e	e	f	g	d	g	g	j	g	b
C.	b	i	f	h	h	c	j	h	e	f	f	g
D.	a	b	b	c	a	b	g	b	j	a	b	c
F.	g	h	h	g	i	i	f	d	h	g	j	h
K.	j	f	j	i	j	j	e	j	i	d	i	j
L.	i	d	i	f	d	d	i	e	f	c	c	f
M.	h	e	d	j	e	h	c	c	c	h	h	e
P.	c	a	a	a	g	a	a	a	a	b	a	a
S.	d	c	c	b	c	e	h	i	b	e	e	d

In the experiments upon Byron and Keats, subject A. was the only one who gave longer tappings for the pleasant than for the unpleasant lines; D., L., and P. do the opposites in both cases;

all the rest of the subjects are apparently inconsistent. In the experiments upon Arnold and Tennyson subjects B. and C. give the longer tappings to the pleasant lines; D., K., M., and P. do the opposite, and the rest of the subjects are again self-contradictory, to a more or less degree. The apparent conclusion is,—new material, new motor manifestations.

Both of the rank lists for the mean (Arnold and Tennyson) are splendid,—indeed, they are rarely ever so consistent thereafter. But the rank lists for the mean variation and the range are not as consistent as they have been before.

From the graphs for this work it was noticed that in every case, the Tennyson experiments took a shorter time to be spoken than did those of Arnold. Also in graphs X to XII appeared much more form quality in the Tennyson than in the Arnold graphs. Even in the final average for all twelve experiments this character is well defined. Again it is concluded that there is something about the sounds or the arrangement of the sounds in the Tennyson experiments which caused the fingers of the ten subjects to move eighteen metres more while tapping the Tennyson experiments than while tapping those for Arnold.

We find also that characteristic feeling-tones, moods and the like are correlated with the type of motor discharge which accompany them. Where one is individual and significant, so is the other. Not only were the Byron graphs indicative of a greater length of tapped strokes than those of Keats, and the Tennyson than the Arnold, but also the general appearance, the steadiness, the form of the graph began at least at the tenth experiment on these poets, and very frequently before this, to take on an individuality as drawn on paper, as much as did the content and quality of the lines as spoken and understood. So that the motor expression we had used, namely the tapping movements of the right index finger, appeared to be not only one that tended toward automatism, but also one that drained away the general somatic supply in a manner characteristic to the poet and fitting to the purpose in hand. A fair analogy to this is found in the case of singers sympathetically accompanying

themselves upon the piano; where the two forms of musical expression are identical, at least functionally, in so many ways as to be regarded as indicative of that unity of the esthetic consciousness which in this particular instance expresses itself in blends of behavior.

To take up each poet or each pair of poets who were experimented upon would be too tedious, and so we shall now turn to a consideration of the rest of these 240 experiments only insofar as they supply data for the main thesis involved in our problem. At the end of the series there appear two very interesting tables, which summarize and focus the matter of the correlations in a very interesting way. One generalization is not out of order in this connection,—the lyrical poets, as every literary man well knows, have employed a phonetic device which the other poets have not; name the lyric poets, and you name the users of liquid sounds in their poetry; name again the lyric poets, and you have named those not only whose lines transmogrify best, but also those who will produce in these tappings, as recorded in the graphs, the finer form quality of the curve of the motor discharge.

At the end of the introspective and other reports of the experiments upon these remaining sixteen poets, we shall consider the graphs for all of them.

Coleridge I. Thŭ nāse tă nēēl rĭ tăm dĭn rāde thŭ lēēr.

Reminds him of the sound of cymbals.
Sensations cluster around "n" and "s."
Very highly colored sounds.
"E" is conspicuous; imagery of the sea.
Stays in the mouth.
Consonants more prominent than the vowels.

Coleridge IV. Rŭ thăd thă bāng tĭs lēēt stā rŭsk tĭ pā. From "Beat its straight path along the dusky air."

Visual imagery of rustic scenery; simple concept.
Sounds run back and forth in the mouth.
Hard to say "sta rusk." Rather quiet sounds otherwise.
Sounds like water gushing and then flowing smoothly.
Something Russian about it; more epic than lyric.

Coleridge V. Rĭ vōze kā strŏn sŏv mōrst bā fănd thŭ wāme. From "A storm of waves breaks foamy on the strand."

Has a funereal air; imagery of scenes of death.

"Wame" means country life.
Images somebody laboring under a burden.
Felt as if standing at bay, in desperation.
Forceful; hard sounds, but not unpleasant.
Sounds like a strong rebuke.

Coleridge VI. Thŭ zûrv lĕs nōōm äll blĕthĕr wĭldĕn fōge. From "All golden with the never bloomless furze."

Some idea of blessing, or piety called up.
Seems like the last words of a narrative of fighting.
Weather and fog and ocean thought of.
Gives a cold and lonely feeling.
Something cloudy and wild and inconsistent about it.
Gives him a "fuzzy" feeling; ghost story.

Wordsworth I. Thŭ rĭn dĭn lāse ră zēēm tĭ rĭt thŭ tāne.

Very natural sounds; gives a relieved, placid feeling.
Too nasal; imagery of skipping along.
The whole line a balance between soft and loud sounds.
The "t" sound predominated.

Wordsworth IV. Thŭ grēēm thăt brĭllz tōōr zŏng ănd hōvez ă thāne. From "That nature breathes among the hills and groves."

Thinks of the "Lady of Shallott" and of "Launcelot." In spite of the "g" sounds, it seems far forward in the mouth.
Felt in the nose; imagery of fields in a brilliant green.
"Greem" gives a shock; "zong," "toor" and "hoves" bring up bovine concept.

Wordsworth V. Ov tāthe ĭm tōse rō sĭ hăv lōrs tăl mēēz. From "Our souls have sight of that immortal sea."

Recalls moral ideas.
Sounds all pleasant.
Very easy to say; vocalized well; no imagery.
Once almost got a meaning but lost it.

Wordsworth VI. Hōō krŏn thŭ sĕt wĭth stădz ŏv nīdĭng bōm. From "Who crossed the sands with ebb of morning tide."

Sounds important; "kronz" = crowns.
Epical sounding thing.
The "z" sounds very effective.

Shelley I. Nĭd rĕn dăt rŭl tăl mēēd rŭn tĕs thĕr nŭl.

Every foot pleasant, but the line disconnected.
Front of the mouth used.
Sounds do not fuse; each foot is distinct, yet smooth.
Sounds gloomy and melancholy.
Surprised because it went so smoothly; especially since all the sounds are short and emphatic.
"Ther null" meant "thermal," "diurnal"; very resonant.
The "d" and "t" sounds predominate.

Shelley IV. Whĕn sŏv thŭ nĕsh dōl grĕss hēr thŏn thŭ rē̄ē. From "When on the threshold of the green recess."

Mediocre poetry; the "s" sounds mar it again; "sov" makes the lips come into focal consciousness.

Very strong rhythm.

Lyric sort of a thing. Visual imagery of out doors.

Shelley V. Bē quĭvĭng thēēnērd zärm our twītēr nīn. From "Quivered beneath our intertwining arms."

Refers to some very romantic scene.

Something akin to coquetry thought of; slight sexual feeling connected with it.

Arouses many emotions.

"Twiter" particularly pleasant.

"The R sounds prominent."

Shelley VI. Thăt flōgy lōōth ŭp lĕngērz mĭv ăt rŏn. From "At length upon that gloomy river's flow."

"Flogy" seemed sexual; conscious of the roof of the mouth.

"Flogy looth" is a lovely, slippery combination; thinks of seaweed on the rocks.

The "g" sounds suffocate.

Gives that feeling of uneasiness one has when shadowed.

Marlowe I. Rĭn tĕn thŭ rīle dă zāde ŭt sī thĭ nĕt.

Great variety of sounds in it.

Seems to occupy the middle of the mouth cavity.

Very little buoyancy or warmth.

Something explanatory; expansive feeling.

Marlowe IV. Thŭ dĕnchĭlz qūāre ĭn chĕvlĕss fānez ŏv thīre. From "The devils there in chains of quenchless fire."

Feels lips touching eye-teeth; thought of something tragic or mock heroic.

Forceful sounds; thinks of "fame," "Macbeth," etc.

Very energetic and sturdy; sounds forward in the mouth.

Epic line; invites bellowing.

Marlowe VI. Thŭ wûrj ōr tĕkt bē drōōt nă sēr dră mûrld. From "Be termed a scourge and a terror to the world."

Seems around the front of the mouth.

Thinks of the growling of a lion; wild and forceful sounds; they fill the mouth full.

Too many consonants; feels like being whirled about in a circle and left breathless.

Sounds like angry swearing.

Cowper I. Nŭd răs tĭ nĭl mă zĕt rĭn dĕs dŭ răn.

Tiresome, disconnected sounds.

Seemed to be inhibited.

"If said low and quietly, it was pleasant."
Gives an attitude of confidence.
Sounds like the narrative of a traveler.

Cowper IV. Thŭ nĕm thăt hīfe ăs văn dĭ mēēdz ăz dīre. From "The deeds that men admire as half divine."
Located at the lips; kinaesthesis the basis of the pleasure.
Gives a vague idea of something confidential.
The "ad van" very prominent.

Cowper V. Wĭth nĕrn ĭ pĭd ănd ŭs kŏn tĭ ră năd. From "With mad rapidity and unconcern."
Has a silly and foolish meaning.
Located forward in the mouth; imagery of indefinite activity.
Prevalence of short vowels noticed.
"Us" is peculiar to accent; this the focal point.
"Pid" balks one; induced a feeling of spunkiness.

Cowper VI. In shûrz rē kōzemĕnt zŭv thŭ fōre hē lĕnt. From "Incurs resentment for the love he shows."
Feels it located back in the mouth.
Not very energetic; gives a cool effect.

Milton I. Thŭ rĭl tĭn lēēt rē tīse dă nĕd nŭ rō
Front part of the mouth in consciousness.
First two feet give a sense of levity, last two, gravity.
Not emphatic, but most agreeable and lovely; gave many pleasant thrills.
The "t" and "n" sounds tended to interchange.

Milton IV. The dĭz ănd tīld yōō wĭs shŭn wā măl sāte. From "The dismal situation waste and wild."
Thought of the words "wistful way."
The sounds feel frigid; imagery of a cold country.
Very easy to say; sounds like an oration.

Milton V. At bōze hē chăn tĕl măst hĭz twĭlt ănd rōōl. From "At last he rose and twitched his mantle blue."
Suggests early English romanticism; maybe fighting; feels as if the front of the mouth alone were used.
Calls up Scotch scenery.
Trace of quiet and melancholy in "bloze"; rhythmic.
Calls up some martial attitude.

Milton VI. Mē tāse ī läwt mī sount ĕs pāze ĕd thäw. From "Methought I saw my late espoused saint."
Very conscious of the mouth sensations.
A quiet, peaceful description.

Rossetti I. Nĭ rĭl thŭr dēte ză mĕs rŭt lē dĭ rĭn.
Kinaesthesis rather forward.

Not musical, but impressive
Felt as if "mes" and "rin" were light spots.
Perhaps a description of nature; "t," "d" prominent.

Rossetti IV. Tōō nŭdz tĕn sprōle tōō zĭng thĭs gīne sĕt wĕs. From "Tonight this sunset spreads two golden wings."

Rhythmical; imagery of a sunset.
"Too zing" and "set wes" charming.
Seems like walking haltingly; five separate feet.
Feels like setting his teeth.
"Z" and "s" quite prominent.

Rossetti V. Thŭ wĕd ŏv dĭnth ĭm sĕr ĭsh wŭble pĭng. From "The wind of death's imperishable wing."

Mysterious and humorous.
Kinaesthesis goes from the throat to the lips and back. Imagery of some red scene in nature.
The last three syllables seemed strangely inadequate.
Seems like climbing a hill to a level path.
Warmly emotional, but no meaning.

Rossetti VI. Thŭ shounding nīse thŭ soudz ă rīte thŭ lōre. From "The sighing sounds, the lights around the shore."

More magnificent than pleasant; visualizes Niagara.
Thinks of the roar of water; sounds dental and palatal.
Thinks of an enormous wide ocean.
Description of an imposing natural scene, either mountains or the sea.

Shakespeare I. Thŭ trĕl tĭn răd nŭr tĭn dăt sī thŭ năl.

Sounds musical and rhythmic.
Seems to lie in the forward part of the mouth.
Has a latent meaning of some kind; very musical.
Very light and lyric.
Melodious; firm sounds, yet not obtrusive.
"N" and "t" prominent, but not hard this time.

Shakespeare IV. A krēē zĕn swĕv thăt zī ĕst hōte ĭn flāre. From "A crow that flies in heaven's sweetest air."

Seems all in the roof of the mouth; visual imagery of a stream, also of flame.
Too many "z" and "s" sounds.
Thinks of some national affair, such as "conditional dependency."
Seems to be a description of a big fire.

Shakespeare V. Thŭ prīme hĕr kŏv zăl bûr lĭ pā krĭ vŭll. From "Calls back the lovely April of her prime."

Kinaesthesis not localizable. Every iambic is an isolated meaning.
Pitch rises to the middle and then descends.
Very mysterious and splendid.

Shakespeare VI. Mē kloum hăth rēēt him frask thũ now jŭn. dŏm. From "The region cloud hath masked him from me now."

Seems to describe a little animal freeing himself.
Kinaesthesis elusive; something energetic about it.
Seems to describe the frisking of a clown.
Describes a jolly May festival on the very green grass.
Very amusing; burlesque; anticlimax;

Spenser I. Rĭn dēēr dŭ nīs tă mīte nŭz rĕl rĭ dēēn.

Felt in the front of the mouth; likes R, M, N, and V.
Hard to say; feels as if the sounds were projected from the mouth.
Nasal, especially the "d-n," "n-d" combinations.
Queer; sort of an old fashioned dignity about it.

Spenser IV. And dĭng ŏv tīns ănd sā dĭs lĕn tŭl jēēdz. From "And sing of knights' and ladies' gentle deeds."

Superficial and humorous; his mouth seemed to wear a grin.
Couldn't get it out of the back part of his mouth.
"Z" too prominent.

Spenser V. Bē dōle ă lā hĭm fīdly vûr dĭ sāre. From "A lovely lady rode him fair beside."

Located forward in the mouth.
Smooth; a ballad of some sort; love poetry.

Spenser VI. Thār dĕz ĕl wŭd ā hăp ĭ chōlĭ fī. From "There was a holy chapel edified."

Something rather profound indicated by it.
Seemed forward in the month.

Browning I. Nĭt rāse tĕth năl răl dēēt thĭs măs nŭs rāne.

Emphatic and slightly humorous.
All feels in the front of the mouth.
Requires more mouth movement than is normal.
Tends to get a little cumbersome.

Browning IV. And blĕm thŭ vēē dē tŏs tĕr hăs thŭ mûr. From "And hear the blessed mutter of the mass."

Sounds on the lips mostly; thinks of ocean and the mermaids.
First amusing, then unpleasant.
"Blem the vee" is swearing.
Arouses feelings of disgust, possibly scorn.
Sarcastic meaning.

Browning V. Hē kŭl tănt ĭb rē thōo nĕs pûr thŭ lĭz. From "He threw reluctantly the business up."

Sounds in the front of the mouth; unpleasantly comical.
The sounds do not go together.
Very commonplace description.

Browning VI. Năd rī vōōk ĭl tĕn thōr hăb tē thŭ sŏn. From "And I have written three books on the soul."

Sounds in the middle of the mouth.
Certain warm quality about the sounds.
Seemed to demand a rapid reading.

Pope I. Nĭ rŭn thûr tĭl tŭ zĕd răs nŭs nĭ rĭt.

Has a nasal twang.
Tip of tongue used too much; not rhythmic.
Too many "n" sounds; gets tongue-tied.

Pope IV. Thŭ shûrn ō blēke hĭz nŭslĭ stōōbĭng rā. From "The sun obliquely shoots his burning ray."

Gives a cold, unhappy sort of feeling; thinks of snow.
Smooth and rhythmic; thinks of a windy, sunshiny day.
"Nusli" and "stoobing" very bad sounds.

Pope V. Thŭ loundĭng săts ĭn rōōp ĕx tûr dĕr tōr. From "The troops exulting sat in order round."

Thinks of a camp fire and of baking.
Sounds like a title to something odd.
Jerky and full of irregularities.

Pope VI. Thŭ snoud ănt kēēs mŭ sĕn ŏs tōō thŭ mĕs. From "The sound must seem an echo to the sense."

Thinks of forced punishments.
From the sublime to the ridiculous, Foot I to V. Here the sibilants are not unpleasant.
Sounds like a sarcastic remark.

Jonson I. Nĭt lĭn thŭ tā răn dĕs dŭ thāne tĭ rĭl.

Full of dentals; feels tongue pushing about vigorously.
Kinaesthesis at the hard palate forward.
Fairly smooth and open; forward in the mouth.
Visual imagery of bright colors, no objects.

Jonson IV. Ōr krăngthĕr hĕst hĕr măt ă rĭstăl rēbe. From "A crystal mirror hangeth at her breast."

A romantic note to it.
"Krangther" called up a blacksmith shop.
The "r" sounds very prominent.

Jonson V. And moice hĕr vīke ĭz trĭlpĕt shroud ă lŭll. From "Her voice is like a trumpet, loud and shrill."

Depressing, heavy and dark; cannot tell why.
Flowing and easy; visual imagery of a foggy sea.
Thinks of Vikings and pirates.
Dislikes the tonal anticlimax.
Cannot explain why it should be so full of effort.

Jonson VI. Hẽr thrĕst mā hē nī yōō shănd bärt hẽr sōōr. From "And you may see her heart shine through her breast."

Sad and depressing; gives a feeling of helplessness.
Seems to be slightly threatening; the "r" sounds prominent.
"Shand" dominated the whole line.
"Threst" very pleasant.
Might well be a continuation of IV, and V.

Dryden I. Nŭ rĭn tĭth lō răd sēte rĭ lĭd nŭ rāne.

Seems nasal all through; felt damp and wet.
Localized exactly in the middle of the mouth.
The "n" sounds are rather nasal.
Too many of the same sounds caused inhibitions.
Narrative, business like, but not strong.
Felt as if he had been in a damp forest.
"Tith lo" the pleasantest sound of them all.

Dryden IV. Tōō rŏld ĭn lūre tōō stāve thŭ rūse rē tō. From "Resolved to ruin or to rule the state."

It describes some vigorous historical action.
Thinks of Napoleon addressing his troops; "r" did it.
Located extraordinarily far out of the mouth.
Gives a sense of argumentation or exposition.
Suggests melodrama and a villain.
Describes some one's activity.

Dryden V. Thār krĕllĕn zäll nōōs wīkẽrz wāde thŭ rēne. From "Their cries soon wakened all the dwellers near."

Related to a scene of action; intellectual poetry.
Imagery of some majestic excitement; "r" does it.
Imagery of a sailing boat, activity; sounds placed back in the mouth.
Gets a sensation of floating.
Imagery of something flowing.
Thinks of a ship sailing out of the harbor.

Dryden VI. Dĭ voundz thār tĭshŏnz thĭd ănd nōō pär bīde. From "And thin partitions do their bounds divide."

Seems to describe some great hurry and excitement. Gets a ringing in his ears.
Seems common and vulgar; the activity has faded out.
The last iambic drops perpendicularly.
Something determined and emphatic about the line.

Swinburne I. Năd rĕn dōr lēse thŭ tą rĭt zēde năt rĕl.

Smooth, and well placed sounds.
Conscious of the roof of the mouth.
Easy to say, but "zede" disturbs.
"T," "d," and "r" prominent.

Swinburne IV. Dūse päwd hĭts wāle hē blŭz răth wärd pĕr slēēm. From "Deep sleep hath warmed her blood through all its ways."

Distinct visual imagery of a fleeing horse.

Thought more and more of a blustering, angry man. Rhythm changed from jerky to smooth and regular.

Sounds like a long list of slang words.

Variety of tonal effects in the line.

Swinburne V. And nā wēte zāre ĭng loi sŏv tĭng thŭ nĭs. From "And noise of singing in the late sweet air."

Glimpses of Polish scenery in the imagery.

Suggested some love scene; serenade, or sweethearting.

The long vowels have a warmth about them.

Thrills in the body at "na wete zare. . . ."

Swinburne VI. And rast thŭ vĭngyĕr pănd thŭ spŏtĕrd wĭn. From "And past the vineyard and the water spring."

Feeling of action and strength.

Kinaesthesis very interesting, but cannot locate it.

"Yer" sounds vulgar.

Sounds scratchy, metallic and rasping.

"Yer" made the whole line seem slangy.

Gray I. Thŭ lēre nĭ dāse ră tăm dĭ nāse tŭ lē.

Rhythmical and smooth; sounds like Scottish poetry.

"Di nase" to nasal.

"R," "t" and "d" prominent.

Gray IV. Tōō lē thŭ mawn dŭp mŭs lăn ŭt thŭ pŏn. From "To meet the sun upon the upland lawn."

Visual imagery of a brook and a sunrise.

Has a feeling of eating something soft; "l" the prominent sound, calls up imagery of water.

Imagery of sky, moon and clouds; sounds rather nasal.

Description of rural scenery.

Gray V. Thŭ hûrpĕrz hēkelĭ zāre ănd mō yōō spĕd. From "And spare the meek usurper's holy head."

Visualizes a scene of activity in the harvest fields.

Rather throaty; thinks of crickets chirping.

Imagery of the mown hay.

Flows together; visual imagery of reapers.

Describes some monotonous activity.

Gray VI. And sāre thŭ dĕz ĭts wŏnĕrt stānĕss wēte. From "And waste its sweetness on the desert air."

Gives a tinge of sadness; does not imply activity.

The line is as smooth as water; seems very dental, too.
Seems like running down hill; sibilants prominent.
Short "o" and long "a" do not fit together.
Could be easily memorized; "wete" a very comical ending.

Sydney I. Thŭ rā nă sĭt rē vŭn tĭth lē nŭ rāle.

In front of the mouth more than in the back.
Lyric quality; yet somehow hard to say.
Cannot be said very rapidly.
Tonal warmth about it.
The vowel sounds predominate.

Sydney IV. Hē wŭnz my hōne ĭt wŏz hĭz lärt fōr zŭv. From "He loves my heart, for once it was his own."

Rhythmic and easy to say; narrative; sexual ideas aroused.
Sweet scenes between lovers thought of.
Sounds like gossip.

Sydney V. Wĭth plēē ture nāzed kŏn tĕz ĕnt cāse wĭth prĕnt. From "With nature pleased, content with present case."

Thinks of wooing, pleading and the like.
Thinks of the links of a chain.
"Nazed" is a participle.

Sydney VI. Thŭ nōōr nō wĭz thŭ sĕlth rē prēēl zăm pĕrz. From "The poor man's wealth, the prisoners' release."

Very smooth and rhythmic; might be a deprecation.
Had to pause after selth."

Of all these twenty poets, Byron, Keats, Arnold, Tennyson, Shelley, Shakespeare, Coleridge and Wordsworth show best in the rank lists, and their effect on the introspective consciousness was quite superior to that made by the other eight poets.

The table next to be given needs some little explanation; across the top of the page are written the abbreviations of the ten subjects who took part in the work; the column at the left contains the names of the twenty poets experimented upon. Below the abbreviations of the subjects' names are found three columns with the figures 1 and 2 in various positions under the symbols $\frac{P}{U}$, $\frac{P}{N}$ and $\frac{U}{N}$. The numerator of these verbal fractions is referred to by the number 1 in the columns below them, and the denominator is referred to by the number 2 in the same columns.

Now when the $\frac{P}{U}$ column has a number 1 in it, it means that the average of the tappings for this or that subject were greater for the pleasant (P) experiments than for the unpleasant; when there is a 2 under this verbal fraction, it means that the unpleasant experiments produced the greater motor discharge. And the same for the figures under the symbols $\frac{P}{N}$ and $\frac{U}{N}$,—when there is the figure 1 under $\frac{P}{N}$ it means that the averages of the tappings for the pleasant experiments were greater than for the neutral, and the same way throughout the other symbolic representations.

So that we have a concise summary of the correlations between the feeling tone and motor discharge for these 240 experiments, with respect to the mean of the tappings, all on this one page. If we ask, then, who are the absolutely constant subjects, the answer is that they are in the null class; for in every vertical column we find the ones and the twos scattered all through, with only tendencies of one kind or another looming large. Where there are no figures in a column, it means that there were not enough different judgments to make a correlation: for example, there were in A's judgments on the affective value of Keats' poems, no neutral predicates attached to the experiments, and so on. In D's judgments on the Shakespere experiments, there were only one kind of predicates given, and so in the columns in which there are no figures for a certain poet, we have slight basis for correlation.

Following this page, we have another table, which shows the same correlations over again, and also the correlations between the mean variation and the feeling tone; the figures mean the same as before, and here one can see a very much better correlation than with the mean alone. This is the conclusion: that upon consideration of the preponderance of twos in the first two columns, our former statement is again verified, that it is not the pleasant experiences in these experiments which call for the greatest amount of motor discharge, but the unpleasant and the neutral.

Subject / Poet	A. PU	A. PN	A. UN	B. PU	B. PN	B. UN	C. PU	C. PN	C. UN	D. PU	D. PN	D. UN	F. PU	F. PN	F. UN	K. PU	K. PN	K. UN	L. PU	L. PN	L. UN	M. PU	M. PN	M. UN	P. PU	P. PN	P. UN	S. PU	S. PN	S. UN
Keats	1				2			2		2				2		1	1	2	2	2	1		2	2	2	2	1	2	1	1
Byron	1			1	1	1	2	1	1	2			1	1	2		1		2	2	1	2	2	2	2	2	1	2	2	
Arnold	2	2	2	1	1	1	1	1	1	2	2	2	1			2	2	2	2	2	2	2			2	2	1	1	1	2
Te.nyson	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	2	1	1	1	2	2	2	1	1	2	1	1	1		
Wordsworth	1			1	1	1	1	2	2	2			1	1	1	2	2	2	2			2	2	2	2	2	1	1		
Coleridge	1	1	1		1		1	1	1	2			1			2	2	1	2			1				2				
Marlowe	2	1	1	1	2	2	1	2	2	1			2	2	1	2			2	2	1	1	1	1	2	1	1	2		
Shelley	1	2	2				2	2	1	1			1	1	2	2	1	1	2			1			1	1	2	1	1	1
Milton	2	2	1	1	2	2	1	2	2	2			1	2	1	1	1		2			1	1	1	2	1	1	2	1	1
Cowper	2	2	2	2	1	1	2	1	1	2	2	1	2			2			2	2	1	1	1	2					1	
Shakespeare	2	2	2	1			1						2	2	2	2	2	2	1			2	2	2		1		1	1	2
Rossetti	2	2	1	1			2	2	2				2	1	1	2			1	1	2	2				2		1		
Browning	2	1	1	2	1	1	2	1	1	1			2	2	1	2	2	1	1			1	1	1	2			1	1	2
Spenser	2	2	2	1			2	1	1	2	1	1	2			1			2			2			1	1	2	2	2	1
Jonson	2	1	2	1	2	2	2	1	1	1			1			2			1			2	2	2	2	2	1	1	2	2
Pope	2	2	1	2			2	2	1	1	1	1	2	1	1	2			1	1	2	2	2	2	2	2	1	2	1	1
Swinburne	1	1	2	1	2	1	2	1	1	1			2	2	1	1	2	2	1			1				2		1		
Dryden	2	2	1	2			2	2	2	1	1	1	2	1	1	2	1	1	1	1	2		2		2	2	1	2	2	1
Sydney	1	1	1	1	2	2	2	2	1	2				2		2	2	1	1			2	2	2		1		1	1	2
Gray	1	2	2	2	2	2		2		1	2	2	2	2	1	2			1	2	2	2	2	2		2		1		

Subject / Poet	A. PU	A. PN	A. UN	B. PU	B. PN	B. UN	C. PU	C. PN	C. UN	D. PU	D. PN	D. UN	F. PU	F. PN	F. UN	K. PU	K. PN	K. UN	L. PU	L. PN	L. UN	M. PU	M. PN	M. UN	P. PU	P. PN	P. UN	S. PU	S. PN	S. UN
Keats M.	1				2			2		2				2		1	1	2	2	2	1	1	2	2	2	2	1	2	1	1
Mv.	1				2			2		1				1		1	2	2	1	2	2	2	2	1	2	1	1	1	1	2
Byron M.	2			2	2	2	1	2	2	2			2	1	1		1		2	2	2	2	2	1	2	2	2		1	
Mv.	1			1	1	1	2	1	1	2			1	1	2		1		2	2	1	2	2	2	2	2	1		2	
Arnold M.	1	2	2	2	2	2	2	2	1	1	2	2	2			1	2	2	2	2	2	1			1	2	2	1	1	2
Mv.	2	2	2	1	1	1	1	1	1	2	2	2	1			2	2	2	2	2	2	2			2	2	1	1	1	2
Tennyson M.	1	2	2	1	1	2	1	2	2	1	1	1	2	1	2	1	2	2	2	1	1	1	1	2	1	1	1		1	
Mv.	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	2	1	1	1	2	2	2	1	1	2	1	1		1	
Coleridge M.	1	2	2		1		2	2	1	2			2			1	1	2	1			2				1			1	
Mv.	1	1	1		1		1	1	1	2			1			2	2	1	2			1				2			2	
Wordsworth M.	2			2	2	2	1	1	1	2			2	1	1	1	2	2	1			2	1	1	1	2	2	1		
Mv.	1			1	1	1	1	2	2	2			1	1	1	2	2	2	2			2	2	2	2	2	1	1		
Shelley M.	2	1	1				1	2	2	2			2	1	1	1	2	2	1			1			2	2	2	2	1	1
Mv.	1	2	2				2	2	1	1			1	1	2	2	1	1	2			1			1	1	2	1	1	1
Marlowe M.	1	1	2	2	2	1	1	1	1	1			2	2	1	1			2	2	2	1	1	1	1	1	1	1		
Mv.	2	1	1	1	2	2	1	2	2	1			2	2	1	2			2	2	1	1	1	1	2	1	1	2		
Cowper M.	1	1	1	1	2	2	1	2	2	1	1	1	1			2			1	1	1	1	2	2					2	
Mv.	2	2	2	2	1	1	2	1	1	2	2	1	2			2			2	2	1	1	1	2					1	
Milton M.	1	2	2	2	2	2	2	2	2	1			1	2	2		2		2			1	1	2	2	2	2	2	1	1
Mv.	2	2	1	1	2	2	1	2	2	2			1	2	1		1		2			1	1	1	2	1	1	2	1	1
Rossetti M.	1	2	2	2			1	1	1				2	1	1	1			1	2	2	2				1		2		
Mv.	2	2	1	1			2	2	2				2	1	1	2			1	1	2	2				2		1		
Shakespeare M.	1	2	2	2			2						1	1	2	2	1	1	2			2	1	1		2		1	1	2
Mv.	2	2	2	1			1						2	2	2	2	2	2	1			2	2	2		1		1	1	2
Spenser M.	2	1	1	2			2	2	1	2	2	1	2			1			1			2			1	2	2	2	1	1
Mv.	2	2	2	1			2	1	1	2	1	1	2			1			2			2			1	1	2	2	2	1
Browning M.	1	1	2	1	2	2	1	2	2	2			1	1	1	2	1	1	2			1	1	1	1			1	1	2
Mv.	2	1	1	2	1	1	2	1	1	1			2	2	1	2	2	1	1			1	1	1	2			1	1	2
Pope M.	2	2	2	1			2	1	1	2			2	2	1	1			2			2	1	1	1	1	2	2	2	2
Mv.	2	2	1	2			2	2	1	1			2	1	1	2			1			1	1	2	2	2	1	2	1	1
Jonson M.	2	2	2	2	2	1	2	1	1	1			2			2			2			2	2	1	1	2	2	2	2	2
Mv.	2	1	2	1	2	2	2	1	1	1			1			2			1			2	2	2	2	2	1	1	2	2
Dryden M.	1	2	2	1			1	1	2	1	1	2	2	2	2	2	2	2	1	2	2	2	2	2	1	1	1	1	1	1
Mv.	2	2	1	2			2	2	2	1	1	1	2	1	1	2	1	1	1	1	2	1	2	2	2	2	1	2	2	1
Swinburne M.	2	2	1	1	2	2	2	2	1	1			2	2	1	2	2	1	2			1				1		2		
Mv.	1	1	2	1	2	1	2	1	1	1			2	2	1	1	2	2	1			1				2		1		
Gray M.	1	2	2	1	1	1		2		1	2	2	2	1	1	2			2	1	1	1	2	2		1		2		
Mv.	1	2	2	2	2	2		2		1	2	2	2	2	1	2			1	2	2	2	2	2		2		1		
Sydney M.	1	2	2	2	2	1	1	1	2	1				2		2	2	1	1			1	1	1		2		1	2	2
Mv.	1	1	1	1	2	2	2	2	1	2				2		2	2	1	1			2	2	2		1		1	1	2

The same features were noticed on the graphs for the last sixteen of these poets as were brought to our attention before;—the more and more meaning the line of poetry contained, the finer and finer was the form-quality of the graph as drawn on these plates; experiments X to XII for every poet show the same effects in these drawings,—the first foot of the line and the last foot of the line called for a greater motor discharge than did the intermediate feet. Particularly irregular were some of the graphs, especially those of the less lyric poets; and it not infrequently happened that the rearranged line was provocative of a less regular and rhythmic effect than the transmogrifications which preceded it. Indeed, the experiments numbered VII to IX were not very much enjoyed by the subjects, but, having begun that way, it was argued as a better policy to continue to the end in the same manner as we had begun, so as not to spoil the symmetry of the work.

With nine of the twenty poets experimented upon, the same material was used in experiments III to XII. Thus we had both introspectional and graphical results upon the same tonal content of poetry cast into three forms,—transmogrification, rearrangement, and full meaning. Introspectively, however, the results were not equal: frequently the transmogrification would be pleasant, while the other forms were unpleasant, and vice versa. When this occurred, however, the graphing showed analogous changes. And when the position of a strong consonantal combination was transferred from one part of the line to another, in the same way the graphings showed a shift of accent in the same direction. That tonal replicas were obtained in the transmogrifications without betraying the meaning was evidenced by the fact that in many of the cases the two forms in which the line stood were associated together by the subjects of their own accord. Transmogrifications also always preceded those lines from which they were taken in order of presentation.

Insofar as the graphing of the 81 experiments for those poets whose single line experiments were repeated three times in three different forms were concerned, the results showed that the ex-

periments X-XII always took the shortest time to be spoken, which is quite natural, since they are in the English language; the rearrangements take the next longer time, and the transmogrifications take the longest time to be spoken. There are special cases where the three graphs are very close together, and again other special cases where they are very far apart from one another; Spenser, Cowper, Pope and Milton illustrate the first tendency, while the rest of the poets, more or less illustrate the second. There are also great differences in the angle of inclination of these graphs from the horizontal axis, which is greatest for those experiments which were the most puzzling and the most difficult to recite and introspect upon.

Transmogrification of Large Passages of Blank Verse

We now turn to the experiments concerned with the psychomotor effect of large passages of poetry. These are numbered XIII, XIV, etc. The plan was as follows: to find a ten-line passage of blank verse containing nothing but iambics,—this to be called No. XIII for each poet. Experiment No. XIV transmogrifies this same passage. Experiments XV *et seq.* are concerned with the effect of other than blank verse lines, namely rhymed passages and shorter or more irregular verse forms than the heroic blank verse.

It was very difficult to construct these XIV experiments; it was also very difficult to find the XIII experiments;—in several cases larger passages than the ten lines we used were boiled down to make them, and often it was tedious and slow work; we may have done injustice to some of the poets,—certainly now and then the succession of iambics is doubtful, as in the Arnold XIII experiment. But any one who tries to find ten lines of blank verse poetry without an alteration in the feet, will be persuaded at the end of his search to withhold severe criticism upon the selections of poetry we have made.

To transmogrify these XIII experiments we first wrote the poem on a large card marked out in small squares, indicating the accented consonants and vowels in red ink, and the unaccented in black; the card was then cut up, a line at a time, and the trans-

mogrification was accomplished by uniting the scattered elements again with the tonal pattern of the poem in mind and the injunction to avoid making words or suggestions of words in the tonal product that resulted.

We never presented experiments XIII and XIV for the same poet on the same day; and since intervals of a week elapsed between the presenting of experimental material to the subjects there was little danger that they would recall the work of the week previous; these experiments were presented in the order in which we give them, one of the XIII and one of the XIV on the same day; it was at the close of the hour, also, after the single line poems had been treated experimentally. A brief period of rest was given before we attempted this heavy work, and since the subjects had been tapping for thirty minutes, with rests, the practise curve for the day was not likely to show in these experiments.

Two preliminary experiments of this sort were tried before it was determined to carry the experimentation in this direction. The poets selected were Coleridge and Keats.

The poem from Coleridge so treated was the "Ode to the Departing Year." The first sixty-five accented and the first sixty-five unaccented sounds were employed. For the benefit of a tonal comparison of the original and the transmogrification, we print them both:

Original:

Spirit who sweepest the wild harp of time!
It is most hard with an untroubled ear
Thy dark inwoven harmonies to hear! etc.

The transmogrification:

Thŭ spärd ŏf tēēp ĭt swēē nĭth ăn ĕst wärp
Mō trīme ĭt zärk whōo hīld thŭ wēēr ŭld ōv
Ōst ĭb nī därd wŭ när tōō rēēs ĭn ēēm
Thĕt ĕvĭng clāfe ŏn ĭxtĕns mŏng ē mōr
Ī rēē tăl chōlds ĕn fēēnj ĕnd frĭn yăd nīme
Frĕn hō dŭm stīnd ĭts trăv ērd lĭnd ĕss räf
Bŭs tĭm ĭts wĭst lī nŏnd ĭng fīme thŭ närt

Ī răd nĕss mōrf ĭng lärt thŭ lĕn ŏv stēē
Nĭth ĕnt ĕn tō lĭ sīle dē wou dĕss äth
Thŭ clīt ẽrd mō hĕnt clōn ĭng sāpe nī păzd
Whă rĕt mī flăd the frŏng mûr sŏl wănd rĭth
Wĭm fēēs Ī mŏzd ōr yī tĕnt nīzd ă mōōt
Thŭ hī fous hĕss ẽr stī ĕm yō hĭs sŭl,—

One difference that will be at once noticed between this and the original is that here we have nothing but iambics, while in the other the feet do not remain so regular; neither is there anything in the transmogrification but decasyllabic lines, which is by no means the case in the poem Coleridge wrote. But our rhythm and line form was unchangeable for methodological reasons.

The subjects were all handed this experimental material printed and with the accented syllables marked with a red accent-stroke. They were not told what it was; each one read it over until the pronunciation was well learned, usually four or five times; no pauses were allowed, since we wanted the fresh impression to go into the introspection. When they felt sufficiently confident, the lines were recited and tapped as all the previous experiments had been.

This is the introspection:

Subject A. (We shall omit the feeling tone judgments in this series, for they were all pleasant.) Rather tragical and solemn; organic sensations of a marked character appeared all through the reading; felt that something was impending and tried to shake off the feeling, but couldn't; line four is the important line,—it is very descriptive of some battle or personal conflict; don't know exactly what it means, but it is very gloomy and depressing; sounds foreign and the imagery of some cold climate was aroused.

B. Imagery of a dark cloudy evening on the wild moor; something fatalistic about it; wind seems to be blowing, some traveler is hurrying to obtain shelter; auditory imagery of the sea, which is stormy and fierce; line four seems to reach some climax, and there is a secondary climax in line eleven; I think of Schopenhauer's philosophy and of some of Byron's poetry, but this is more sincere than Byron; organic sensations of a compelling sort; the whole feeling is intensely romantic and mournful.

C. Did not get as good imagery out of it as it seemed to

promise; romantic and forceful; seems to be a description of some battle or of some scene in which there is conflict.

F. Imagery of some wild scene, maybe at night; line four indicates some clash between persons or things; very romantic and at times solemn and heavy poetry. The last line does not seem to belong to it at all,—the "s" in "hesser" rather spoils the dignified effect of the other lines.

L. It's tragic. There is depicted a scene of the middle ages or some dark tragedy of some sort; very heavy and important thing, and someone is describing either his own deeds or those of another in a very emotional way; some of it is soft and persuasive, and gives variation to the heavier parts; it's all very much in earnest; very full of activity and force,—might be from Othello or the other Shakespearean tragedies.

N. Very powerful thing; means some tragedy or heavy and intense situation; line four is where something dismal happened,—some battle described. "Bus tim its wist," in line seven gives the effect of something conciliatory, or as if one should say, "Well, I accept it, if it has to be so," or something like that; gives a deep sound while saying it; but it lightens slightly at the end.

T. Very mournful and sad; almost oppressive; somebody seems to be grieving over some loss or some calamity; at line four there is a feeling that the fatal moment is reached and there is nothing to do but to endure what is to come; the whole thing sounds slightly barbaric, and Teutonic; might refer to Scandanavia and the Norsemen; seems to refer to men rather than women.

W. It gives a rather light and pleasing effect(!) Thought of a lot of animals; seems to refer to something other than myself, and to be out of doors.

Z. Very dignified and tragical; refers to some dreadful calamity and almost to a gruesome deed in the dark. Imagery of wild country and wilder ocean; all imagery of a dark gray color, and auditory images of the sound of the waves and the wind; highly enjoyable sensation altogether; something seems to be inexorably moving and pushing all before it; line four is where something fatal happens; the rest is not so tragical, but it all seems to belong together.

Y. Almost doleful; certainly tragical and intensely romantic. Means much; imagery of some ocean scene where a storm is raging; everybody is in a state of great fear, and is hanging on for dear life; this is in the first part; the last part is more hopeful. Perhaps it is taken from some one of Shakespeare's tragedies. It certainly couldn't be any light, lyric poetry.

In order to make a comparison between the motor discharge obtained in the above experiment and something else by which it can be standardized, we shall take the next experiment of this sort, the Keats-transmogrification, which again every one of the ten subjects found pleasant, though W only slightly so. Here in each case, we have no possibility of correlation between feeling tone and motor discharge, but only upon the basis of what sounds were employed in each experiment, and see whether, for example, the short vowels or the long vowels give the greater motor impetus, and whether certain consonants seem to have more effect than others in this matter.

The other transmogrification was constructed out of Keats' "I stood tiptoe upon a little hill." We employed the first fourteen lines in which there are more unaccented syllables than accented, though the accented sound elements outnumber the unaccented, as is the case generally with Keats as well as most of the English poets. In making the transmogrification of the above passage, these supernumerary sounds had to be omitted; so did the rhyme, as a matter of course, and hence the effect of both fourteen-line passages of sound is not quite the same. Yet the introspection seemed to neglect these differences.

The transmogrification of this poem of Keats:

Ing lŏŏd Ī pō pĭt tĭll ă vĭlly stŏn
A stōōk ŭl rĭt să wănd ŭ stō thŭ rā
Sŭ hĕm whēēt bīde thŭ prĭth ĕst ōōds swĭch ŏd
In wōōp ŭl drănt ĭng lăt ă thûrv ĭng sănt
Pĭng slĕms lĭ kīde ă sklēēv rănd fīde lĭ prat
Thăd stŏn yāte ŏst ōze när thŭ tīămĕds
Mōrf stäwt ĭ hẽrl thŭ lŏd ĭng sōōv thŭ nōr
Nănd owds ōō mẽrb hăs flŏsh thŭ clōōry pōrn
Thănd whyks crēēl tĕsh wŭ frēēt lĭ brŏm ă slŏŏk
Thŭ swŏn ŭ blĕpt thĕ frĕn ŏv hēēldz ĕ crĕv
Thŭ lĕpt lĕss foiz ănd oiz när thĭt ĕl Ī
Thŏv ōrn ă vŏng ĕns bēēl thŭ mēēvz ă sĭl
Thŭ hĕrĭ fāvz năt sōnt ōr mŏt thŭ sŏŏd.

In line eleven one finds an alliteration "foiz and oiz," and line nine is not free from enunciation difficulties, but the above ar-

rangement of sounds was the best that could be done at the time. It was, for some reason or other, much more difficult to keep words from forming in the making of this transmogrification than in the case of the rearrangement of the Coleridge Ode. This one took longer, and more changes were made in it before it was finally presented. Rhymes are particularly troublesome things to handle,—the danger of alliteration is great, for they must be used as near to each other as passible, if one wants to keep the thing a tonal replica of the original.

The subjects gave the following introspections:

A. Slightly humorous thing; very peculiar sounds reminding me of something playfully done; visual imagery of an outdoor scene, quite full of color; whenever the long "I" occurred, it made me think that someone was telling what he had done, but it did not seem very important; this whole combination of sounds less solemn and effective than the other (Coleridge). Something rather quaint about it all.

B. It puts me in the midst of some natural scene, where there is quite a little animation; nothing heavy at all, might be in spring or summer; makes my mouth feel just a little bit puckered, all the sounds seems to cause much movement of the lips; it is not a very deep or profound thing,—just a sort of playful and slightly humorous affair; nothing philosophical in this passage as there was in the other one.

C. Seemed as though it ought to have been easier to say than the other one, and it reads easier to the eye, but when I came to say it, it bothered me more; I don't get much imagery out of it, but it all seems rather light and gay, in spite of the fact that it is hard to read; so many unusual and almost laughable combinations in it.

F. Gives a very peculiar feeling; half humorous and half otherwise; rather romantic and a little Spencerian in places; "the swon u blept" makes me think of Lohengrin and other fanciful characters of mythology; rather much ado about things of very little real importance. Some visual imagery of pastoral scenes, shepherds and lasses and the like.

L. Romantic, curious sort of a thing; not at all heavy like the last one, but pleasant on other grounds; visual imagery of some quiet scene in the fields, in spring; everything is just slghtly moving and nothing very much is the matter, though now and then somebody seems to be making or trying to make important

that which is not so; parts of it are soft and dainty, such as "thu leptless foize and oize."

N. Dainty and light; reminds me of a bird cocking its head from side to side and chirping slightly; visual imagery of something fresh and green, and nothing very important going on. "Tiameds" means something very pretty and dainty, like an ornament or a gift of some kind.

T. Not at all like the preceding one; its all very light and carefree, although some one seems to be talking quite seriously about it at times; the sounds rather too heavy for the meaning implied; I get plenty of imagery of things pastoral and romantic, like shepherds and flocks, and love making and that sort of things; "flosh the clury porn" means that some one has found something very enjoyable and likeable.

W. Seems to be quicker than the other; no imagery, but a general feeling of haste; a good deal of motion to it.

Z. Very curious and light-hearted sort of a thing; visual imagery of a very fine, clear summer day and everything just right; attempts to be serious at times, but doesn't mean it at all; plenty of color to it, and a great deal of animation; seems to be all in the first person; some one is describing an adventure in a somewhat humorous manner; there may be laughter in it.

Y. Seems to be a description of some incident of pretended importance; very romantic and quaint sort of a thing; some of sounds are rich and musical, and again they become a little too hard to say to keep the impression with which the passage started; seems to go much slower than the sense of it demands; visual imagery of something like a tournament in the middle ages, where everybody is gaily dressed and happy; but the sounds seem to change the mood in places where the appearance of the words indicates no change at all.

The question might well be asked at this point,—upon just what were the subjects introspecting in connection with these transmogrifications? That the passages are fairly faithful to the originals can easily be discovered by checking up the sounds of both the versifications, but whether the subjects were introspecting on Keats and on Coleridge, is another very important question. But it is doubtful whether this can be decided.

The mean of the tappings for each subject indicates that none of them had as free a finger movement in these experiments as they had in those which immediately preceded, which, again, were lower than in the "Nerol" type of experiment. Evidently the

reading consciousness and the introspective consciousness drained some of the motor channels of their usual supply of energy.

Experiment:	Coleridge (Klj)			Keats (Stk)		
Subject	M.	M.V.	Rnj.	M.	M.V.	Rnj.
A.	60.2	1.9	11	63.9	1.4	11
B.	63.8	1.6	16	64.0	1.9	24
C.	70.3	3.6	18	71.0	4.5	15
F.	67.4	4.1	23	69.7	4.0	23
L.	64.5	4.1	13	64.9	3.1	14
N.	69.7	4.6	24	74.0	4.2	21
T.	72.1	4.8	21	76.3	3.7	17
W.	64.2	2.9	20	61.0	2.6	20
Z.	41.9	1.1	13	43.6	1.5	9
Y.	36.8	1.3	9	40.0	.9	8

The rank list of the above:

Experiment:	Klj.	Stk.	Klj.	Stk.	Klj.	Stk.
Subject	Mean		M.V.		Rnj.	
A.	c	d	d	b	b	c
B.	d	e	c	d	e	j
C.	i	h	g	i	f	d
F.	g	g	h	h	i	i
L.	f	f	e	f	d	e
N.	j	i	i	i	j	h
T.	h	j	j	g	h	f
W.	e	c	f	e	g	g
Z.	b	b	a	c	c	b
Y.	a	a	b	a	a	a

The relative positions are fairly well kept in these lists, and indeed better than one might expect in connection with such new material as the above experiments contained. It will be noticed, also, that all of the subjects but one, W., contributed to the increased motor output in connection with the Keats experiment over that of the one on Coleridge. A comparison of the tonal elements contained in these two experiments reveals the following differences:

Accented	Coleridge	Keats
Long vowels	44	34
Short vowels	21	31
Unaccented		
Long vowels	16	49
Short vowels	49	56
Accented		
Consonants	144	152
Unaccented		
Consonants	88	74
Total elements	362	356

From this it would seem that a preponderance of accented and unaccented short vowels together with fewer long vowels of both kinds, more accented consonants and fewer unaccented consonants were capable of being interpreted as giving the greater effect on the motor consciousness. These experiments were not given on the same days; and yet it may be that the week that elapsed between them for each subject was in itself sufficient to make the Keats Experiment easier and more capable of calling for motor output than the other. Yet none of the subjects found the second of the presentations easy; each syllable had to be gone over carefully,—certainly none of them read it at sight. Of the two experiments, the one on Coleridge "took hold" the better, and aroused and perpetuated its mood the more easily.

A more careful examination of these experiments reveals the fact that there are an equal number of accented "h" and "s" sounds; that Coleridge employs more accented "f," "m," "n," "r," and "w" sounds; and that Keats employs more accented "b," "d," "k," "l," "p," "st," "t," "v," and "z" sounds than does Coleridge. The inference is rather clear, that the explosive consonants and the short vowels are what makes the tappings longer in the one case than in the other. One has only to refer to the "Nerol" type of experiments for the same sort of indications; there, likewise, the short vowels were correlated with the greater amounts of motor discharge. Again, too, the "l" sound is allied with the explosive consonants and not with the liquids, but this may be only a fortuitous matter.

From the graphs of these experiments, it appeared that they were quite different both in height and in slant; the Coleridge graph was the steadier of the two and even tended to sink slightly at the end, while the other one rose at one angle of inclination until the eighth decasyllabic line, and at another angle from then on until the end. The short vowels and explosive consonants seem to be both more energetic and more irregular in their effects upon the tapping. Also the greater motor output appeared to take less time.

There follow the eighteen regular XIII and XIV experiments together with the introspection given upon them, after which is given the numerical results and the various correlations.

Keats, Experiment XIII

I stood upon a shore, a pleasant shore,
Of fragrance, quietness, and trees, and flowers;
Too full of joy and soft delicious warmth.
I sat me down, and took a mouthed shell
And murmured into it, and while I sang,
And with poor skill let pass into the breeze
The dull shell's echo, from a bow'ry strand
Just opposite, an island of the sea,
There came enchantment with the shifting wind
That did both drown and keep alive my ears.

Keats, Experiment XIV

Tōō nōrj ŏv zĭl tī stōrănt qūīde ă mûr
And shŏŏl ă prēēz ŏv mōrp ănd thŏnăns lā
Pŭ shoi thŭ flowd ŭp wēērz ī shĭltĭng zōōr
A thoum ĕd frŏl gĕr lŏft ănd tăss ĕt drēē
And kāfe ŭs shĕnd ă jown dē zăng mĕnt ŏl
And shĭth ōōr wĭs ănd strămĕrd wĭt rĭ mănt
Shī nowd ănd wĭth ĕn tăss ī pŏdlănd kŭv
And skēē thăt whĭ zō kŭl tō dōw thŭ frĭm
Thār vī stō zĭt ĭn sōō thŭ strĕbĕl nĭd
Thō chēē năm kĕb ī tĭd thŭ pīfe mē sĕn.

Keats XIV. (The transmogrification of Keats XIII.)

Subject A. P. Cast a visual image of a woodland scene, a stream in it, and then a great number of woodland and water noises until it got very tiresome indeed; seemed to repeat the same thing.

B. P. Seemed to be hard to say and there came imagery of a summer scene, and men in it, probably engaged in some contest or other; it is a narrative, anyway; the "l" sound was very conscious, and the accents were hard to get right; yet the more he read it, the smoother it became; to look at the page, it seems to be full of "s" and "z" sounds, but not while saying it.

C. P. Seems to be a description of natural scenery, woods, trees, flowers, grass, sea water and some one seems to be talking freely about it; but the talk is not as good as what it describes. Kinaesthesis seems rather forward.

D. P. I can't imagine it being any thing else but an out of doors scene that some one is describing or enjoying; there's water there, and everything is peaceful and quite pleasant; it is emotional and the feeling is contagious.

K. P. No exact meaning, or imagery that was dependable came; but it is

a description, and is just a little declamatory, with a note of melancholy, and perhaps, resignation in it; also a certain amount of will and determination.

F. N. Very conscious of the difficulty in saying it, and each syllable felt as if it were a mouthful; no imagery came, only the feeling of laboring at the pronunciation continued throughout. "Podland Kuv" ought to have meant something; could not get away from the strain of reading it.

L. P. This seems more intellectual than lyrical, or at least is not fully, freely lyric; such words as "shilting," "thonance," "storant," etc., are very pleasant; the sounds ran together very well. The tonal quality was epical.

M. P. It looks worse than it sounds; images a woodland scene, and thinks of the "Midsummer's Night's Dream"; there is water in this scene, and somthing weird and peculiar is happening. Would like to read it often and become familiar with it.

S. P. It is describing a natural scene, with trees and flowers and water in it; sense of relaxation in it, the more it is read.

Byron, Experiment XIII

And dreams in their development have breath
And tears and tortures and the touch of joy;
They leave a weight upon our waking thoughts,
They take a weight from off our waking thoughts,
They do divide our being; they become
A portion of ourselves as of our time,
And look like heralds of eternity;
They pass like spirits of the past,—they speak
Like sybils of the future; they have power—
The tyranny of pleasure and of pain.

Byron, Experiment XIV

Thŭ mēēz ă brĕnt ĭn zāre ĭng mĕth dē rēēt
And chĕv thŭ năd ănd thēēlīng pōrtūrz vīde
Thŭ droi nă jā thā plāke ĭts spĕrăld hēre
And kŏŏl dăv tŭlz dĭ vŏn shŭn pĕlz ĭn toi
In tāpe thŭ wāke ŏp tōse our kīme ĭts wā
Mōrf stäwt ĭ bĭs thā tŭv ăz nā līke wē
Kī thā tūr fĕz ŏv năd row fŏm bē rēēt
How kāde ăs pŏv rā wēēt lā kăssŭng fŏv
Văl tûr thŭp sēēb ŏv pûr thā towp ŭr thōō
Rā vĭth ōōr vŏl tā kī thŭs ŏv thŭ rēē.

Byron XIV. (From transmogrification of Byron XIII.)

A. N. It describes action or scenery; the meaning is vague and elusive; doesn't seem to run smoothly and evenly, and gives him a feeling of tension.

B. P. Gives a feeling of something portentous, but very enjoyable, even if it is fearful; is quite determined and full of energy, and might be said very loud; it seems to be held back all the while.

C. P. Quite tiresome, as compared with the former (Keats); but it means something, perhaps, like a struggle or some activity somewhere.

D. P. Harder to say than the one previous (Keats); liked lines 4, 5 and 9 very much; thought of something rather deadly and threatening; the meaning did not come clearly.

F. P. Goes easier than the former (Keats). Seems to be more creative than the former; is speaking of familiar things in a heavy manner; sounds oratorical, and can be spoken tragically.

K. P. Not quite so pleasant as the former; little declamatory at first, later on is subdued and a little tense.

L. U. Seems like a reporter's account of some event; has no poetic beauty; it is too hard.

M. U. Seemed hard to say; the sounds themselves reminded her of a slave driver, urging somebody on; dreadfully conscious of the effort to pronounce it well, and the emotion aroused was one almost of suffering.

P. P. It was all hard work to say, and about the middle he felt as if some dreadful force was pulling him back.

S. P. The last was static (Keats); this is dynamic; this does not describe still nature, but moving nature; there is no relaxation here as there was in the last one. Not so poetically intense, but more physically intense.

Arnold, Experiment XIII

And Rustum gazed in Sohrab's face and took
The spear, and drew it from his side, and eased
His wound's imperious anguish; but the blood
Came welling from the open gash, and life
Flowed with the stream;—all down his cold, white side
The crimson torrent ran; his head drooped low,
Till now all strength was ebbed, and from his limbs
Unwillingly the spirit fled away,
Regretting the warm mansion which it left,
And youth and bloom, and this delightful world.

Arnold, Experiment XIV

Thŭ gōrt zŏn krāde hĭz lănnĭng wĕllŭs fīde
And tōōz ăb sāke ĭt spēēn ă wāy năd zēē
Hĭz drōōmĭng strēē zĭt nowd thŭ mĭth ĭl grĕm

Rē tĭs ĭn wīle ŭm stûr năd pēēr ĭsh frŏll
Hĭz yōōm ănd rōōth ŭn woun thŭ dăz ĭt lĭng
Kā sō shŭn blī pĕn dōle ănd nowb ŭn thēē
Fŭl thĕng dē thĕl wär spēē thŭ shĕmĭng lōr
Wăs frŏl dō găm ănd chī flănd whĭt ză rŭd
Äll sûr tĭ wĭb ănd wĕft hĭz tī nĭd mō
And blăn ĕnt strĕb thŭ frĭmz drōōm äll thŭ mûrld.

Arnold XIV. (The transmogrification of XIII.)

A. P. Very highly interesting, like the preparation for war or like some very tense and exciting situation; auditory and visual imagery of this,—also the sea entered into the imagery at times; the emotional tone, which was intense, had to do with death or things associated with death; feels "erhabend."

B. P. Attention chiefly occupied with the pronunciation and the kinaesthesis, which was sibilant rather than dental; the passage does not seem very poetical or rhythmical; seems like narrating the virtues of some ordinary poetry. (N.B.—Subject B. likes very erotic and sensational poetry, notably Byron and Keats.)

C. N. Contains a lofty concept, and is probably epical; not very decisive or tumultuous,—at least it does not manifest emotions freely; thought the sounds were produced in the rear part of the mouth; was rather hard to say.

D. P. Sounded dramatic and oratorical; a trifle tragic, but not wildly so; nevertheless it is not resigned; quite hard to say, and seemed to be full of thin, high sounds.

F. P. Slightly laborious here and there; some lines, notably Nos. 5 and 9 went slowly; had no imagery.

K. P. Slightly rhetorical, but restrained in its emotion; felt his own breath and pulse quicken at times; there is tonal and emotional warmth about it,—more so than with any previous experiment. It is not easy to read.

L. P. It might be Tennyson in Swedish or Dutch; was so taken up with the pronunciation that nothing in the way of mood or emotion came.

M. U. It dragged horribly and was hard to say; felt as if the tongue were too large for the mouth; the first five lines began to mean something, but it all tumbled suddenly into nothing again.

P. P. Felt dreadful tensions in the finger, which seemed to be pulling an enormous weight; could not get this out of consciousness, and so no meaning or emotions came.

S. P. Describes some fight or conflict; the feeling is not so intense as it might be; it seems more internal, more like giving oneself needless anxieties.

TENNYSON, EXPERIMENT XIII

There often as he watched, or seemed to watch,
So still the golden lizard on him paused,
A phantom made of many phantoms moved

Before him haunting him, or he himself
Moved haunting people, things and places, known
Beyond the line; the mill, the leafy lanes,
The peacock yewtree and the lonely Hall,
The horse he drove, the boat he sold, the chill
November dawns and dewy-glooming downs,
The gentle shower, the smell of dying leaves. . . .

TENNYSON, EXPERIMENT XIV

Thŭ stŏl dĕn zĕl ĭng gāde ănd mōzärd wēēn
Thŭ lĕn tŏn chăzly fănnŏck paunt ōr thĭll
Bē mĭngz hĭm chŏffĕn mäwzd ōr sōōvd thŭ lōr
Nō shĕn thŭ rawnz tō chēēl thŭ glōney fănd
And nī thŭ sōōmĭng vownz ănd bäwntĭng nĕlf
Rā wōne thŭ nēēvz ă smōld hĭm lōōbry häwn
Thŭ făltŏn plăss ōr hĕmple mē thŭ sōve
Thŭ dĭl hĭm sŏnd ŏv hōte thŭ lōōtrēē dēēm
Bē fōrthĭng glĭd hē towd thŭ pădrĭ yĭll
Sō dēēl ŏv yāme ănd sŏlgĕrn hē thŭ vōre. . . .

Tennyson XIV. (The transmogrification of XIII.)

A. N. Peculiarly baffling sort of a description,—now of nature, now of a person; very much like a sad reminiscence and full of a sombre, wild melancholy; had visual imagery of rank nature.

B. U. Seems like extolling or eulogizing some person for patience and benevolence; did not seem very poetical; the kinaesthesis was chiefly dental.

C. P. Interesting description of something; puts him in a mood similar to that of Gray's Elegy; there is some human interest involved and something is at stake. Very good poetry, and it runs along very smoothly; the kinaesthesis seemed to be more forward than usual.

D. P. Gives a feeling of sadness; dreamy pessimism of a quiet character involved; it does not describe activity, but has to do with some outdoor, natural scene. Prefers lines 6 and 8.

F. P. Full of emotion; visualizes a rich natural scene, full of shade and trees and water; somewhat pastoral in aspect, but not in the feelings one has about it; the sounds flow together nicely, and at times seems a little like a speech.

K. P. It is melancholy and resigned, and is not dynamic; tells a sad story and induces tensions and feelings of restraint at times.

L. P. Full of moral enthusiasm, devotion and the like; may be the description of some medieval character, knight, or noble person; very lovely and poetic.

M. P. Thinks of Chaucer's poetry; interesting and romantic description of a maiden about to have some adventures; the words "fannock," "paunt," and "nelf" very rememberable.

P. P. Gives a rather hypnotic and dazed feeling; the tapping seems enormously labored; likes line 5 the best of all.

S. P. Reminds him of Sohrab and Rustum; got no imagery but had a tense feeling all the way through; may be describing some natural scene.

Shelley, Experiment XIII

Where plants entwine beneath the hollow rocks
Beside a sparkling rivulet he stretcht
His languid limbs; a vision on his sleep
There came, a dream of hopes that never yet
Had flushed his cheek; he dreamed a veiled maid
Sate near him, talking low in solemn tones;
Her voice was like his own, its music long
Like woven sounds of streams and breezes held
His inmost sense suspended in its web
Of many colored woof and shifting hues.

Shelley, Experiment XIV

Thŭ plēēth ĕn tīne hĭz rŏllĭng kŏssĕd spär
Bē stănd whāre hĭvlĭng nīde ă lĕt ĕn slēēm
Thăt skŏllĭng strōnz ŏv lănyŭn bŭf zŭ wōō
And chĕv hĭz lois hō rĕsk ănd pŏn ă strēē
In tĭzh bē lĭne ĭts drāme hē mĭz yōō rēēn
Hĭz shēft săm tewz thār yĕng să vä wĭd flēēk
Lī mŏng hĕr tŭsh ā chēēmd ĭts kēētĭk hō
Hĭz brēēmy vowndz hē däwk ŏv lĕnmōst wĭn
Hăd zĕld ŏv wōpĕn shĭmz hĭm stĕnsĕd hewm
Wŏs vōlĕrd spō kē vĭk sĕt drālĕrz wĭn.

Shelley XIV. (The transmogrification of XIII.)

A. P. Has a feeling that the thing described is a rather unfortunate affair, and deserves sympathy; later comes the idea that somebody is speaking largely of himself, maybe even in braggadocio.

B. P. Visual imagery of the sea shore and people on it; a good deal of the "n-drone" in the poem, and this calls up the roar of the sea; the first four lines are easier to say than the last six.

C. P. Vapory sort of a thing; seems animistic at times; got the idea of

the sun shining and the word "hiz" brought up rather egoistic notions. Kinaesthesis frequently back in the mouth.

D. P. Thinks of a slippery and slidy waterfall; several times it gave a creepy, and crawly feeling; visualized the "Nude descending the Stairs."

F. P. Flows very well; gives an outdoors, cool effect.

K. P. Slightly rhetorical, but not heavy or sombre; very clear and light sounds, and it runs off just as easily as real words do.

L. U. Cannot seem to make it blend; it doesn't fit into any organic rhythm; the fourth line alone good.

M. P. It is first a narrative, and then something very mysterious and like a fairy tale; like the story of some very wonderful thing, told with wide open eyes. Strange that it should sound so foreign and also so familiar.

P. P. The first half is very good, the last not; organic strains come in at the end, and make it pull very hard. "Lanion" is a very good word.

S. P. Describes an adventurous scene; concerned with human life very intimately; gets social concepts about it and maybe an idea of some work or activity.

Milton, Experiment XIII

Before the gates impaled with fire there sat
On either side a formidable shape.
The one seemed woman to the waist, and fair,
But ended foul; about her middle round
A cry of Hell-hounds never-ceasing barked
And rung a hideous peal. The other shape,
If shape it might be called that shadow seemed,
For each seemed either—black it stood as night,
And shook a dreadful dart; what seemed its head
The likeness of a kingly crown had on.

Milton, Experiment XIV

Thŭ mōr ble gīre bē tāse ŏn lāpe thŭ dēēth
Im stā thār fīde ă shālĭng fōrdŭl wēēs
It bowm hẽr sōō mī wĕndly kärb ăn tow
Bŭt kīle ĕd māre ănd krĕlyŭs wŏn ẽr stā
Thŭ lound hĭs nĭngfŭl pēēm wĭth shălldẽr sĕv
It shā zound blēēth ẽr fŭng rō pīle ă chēē
Thŭ dŏŏpnĕss hī bŭt stā dă nŏck dăs hĭd
Whät dēēs thŭ mĕd ŏv shĕmd ă crŭv hăd rĭsh
Sēē tōōd mă dăs ă thŏd mō kowm ĭf hĭ
Nē drŏd bā tärk ăz fŭd rē kōōp thăt rēē.

Milton XIV. (The transmogrification of XIII.)

A. U. Gives a feeling of sombreness, and arouses ideas of death and fatalism; makes him very depressed and he asked himself the question, "what boots it"; consciousness directed toward the sensory side, and felt much strain and tension.

B. P. Gives an idea of some activity, like the chase, or even trouble of some sort; smooth and rhythmic all through; head resonance very pronounced, and the whole mouth cavity seemed to be active.

C. P. Seems to be an exact description of some rough scene, maybe of a rough and rocky country; some event is taking place at the present time, perhaps in the "historical" present. Kinaesthesis not noticed especially; prefers lines 3, 4, and 5.

D. P. It is not emotional and not romantic; seems to be telling about some difficult situation; sounds are hard and rocky, and yet it all blends smoothly together; "d" and "m" very prominent, and "med," "des," etc., particularly noticed.

F. P. Sounds like a bass drum; it pounds along and gives a feeling of strain and force and sometimes harshness, but as a whole it knits together well; the numerous "d" sounds are provocative of strain sensations, and the pleasure comes from doing a difficult task well, or nearly so.

K. P. No very definite meaning to it at all, but in general it is weird and now and then cumbersome; easy to say, rhythmic.

L. P. Not a lyric, but a very serious and heavy narrative; describes something like a tournament, and the shock of arms; could not keep the excitement out of his voice.

M. U. Got very annoyed at it the more she said it; does not think it is at all lyric or gentle; too many "d" sounds, which made it drag and scrape along; for a while it sounded like some of Chaucer, but then she decided it was quite modern; even belligerent at times.

P. P. Line 5 has a meaning, but he did not get it; it ought to mean a lot; the last four lines pulled like everything and strain sensations were felt all over the body.

S. P. It is a narrative of some strong and determined activity all through; seems to be told in the first person; cannot think it is lyric, or gentle at all; did not let himself get into it very far, as he does not like that sort of poetry.

Wordsworth, Experiment XIII

Abundant recompense; for I have learned
To look on nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh, nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy

Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns. . . .

WORDSWORTH, EXPERIMENT XIV

Tōō lĕns ŏv mûrd ă bŭnyōōr noi dănt zī
Nōr stĕllŏm krēē mĕns nāte ĭng vär năd mĕrbz
Lĭ pŏn ă zĕt fōr chăddĕn prĕllĭng nowr
Hăv sŏŏltĕr grĕnnĕd yōte ĭng hĭv thŭ kīme
Az thawn ŏn lōōth ăd hŏvlĕss mī thŭ dāse
Dĭs tăm bŭt fewt ōr thāte ĭng mewple nĭd
Tōō hĭftĕn thŏdrĭng jāse ĭk wĕs nī lowr
Hew thī sŏv păf hōōz lawts ō rĭth ē tewd
Sŭb tĕl thŭ sĭsh ă zăt ŏv wĕs ē thŭn
Sŭb tīze thŭ spēē vŏm tŏs hăv nĭz ŏv när. . . .

Wordsworth XIV. (The transmogrification of XIII.)

A. U. Seems to be a vague, meaningless jumble; suspects that it is philosophical; certainly it is not the description of any activity, and does not have anything to do with the common acts of life; not heroic nor epical.

B. P. Fairly smooth and rhythmic; mellow; meant something warm and pleasant; visual imagery of summer scenes, rivers, and green shade and kindred things; idle, rather than active, and musing rather than otherwise; in spite of the apparent number of "th" and "s" sounds, it was kinaesthetically pleasant.

C. P. It is descriptive of nature, and has no climax; runs along easily and smoothly; and the kinaesthesis is quite forward.

D. U. Gave a cold and clammy feeling; even snaky at times; it not active and does not contain anything erotic; imagery of nature, but not in summer; "kremense" gave the idea "cream" = "food."

F. N. Seems to go very freely and easily; many French sounding words in it; no imagery.

K. P. Gets a feeling of resignation, and slight melancholy; noticed the breathing and pulse were quickened toward the end; sounds were not noticed at all.

L. P. Narrative poetry; slightly elevated and epical.

M. P. Quiet and subdued in some places; but often the look of the words disturbs the mood; no imagery.

P. P. Meant nothing as a whole, though several of the words began to mean their phonetic equivalent; goes well and recites easily; gives the feeling that he is hearing some one recite something well learned.

S. P. It is like a description of Nature, perhaps, of the sea, the woods, or hills,—something grand and lofty; there is a tinge of regret in the last three lines, and it seems to be mystically said; went easily and rhythmically.

Coleridge, Experiment XIII

'Tis the merry nightingale
Beside a brook in mossy forest dell,
That crowds, and hurries, and precipitates
With fast thick warble his delicious notes,
With skirmish and capricious passagings,
And murmurs musical and swift jug jug,
And one low piping sound more sweet than all,
As he were fearful that an April night
Would be too short for him to utter forth
His love-chant, and disburthen his full soul
Of music!

Coleridge, Experiment XIV

Thŭ rāle ĭn tĭz mī brĕm dŭs nī zĭk mûr
Wĭth tŭll ĕst crown ăn tōō mẽrz gĕd rĭ kŏs
Jā dīle ĭng mew năd pō gŭ sōōf ĭk näl
Dī fûrdz hĭm swēēfŭl nădrĭz wōrthăn mewb
Wĭth răstfŭl hĭz thăt tĭngz ăz rēēble skẽrth
Dē jownd ŭs lĭst wŏŏd stō tẽr shăndĭk spēē
Wẽr hīle tĭsh fēēchănt lōrsĕj mĭn ănd swō
Bē sĭg ŏv tī mōr bẽr năd few kă păsh
Fōr sĭl thĭs tăv pẽr sāte lăth hĭz nōō shăth
Prē mẽrt zō tā tōō hĭft ĕn prĭnd hĭs wŭn.

Coleridge XIV. (The transmogrification of XIII.)

A. U. Got a conglomeration of feelings and ideas,—the whole mental state was disordered; felt that it meant something, but could only think of something to be prevented; never came to clear consciousnss.

B. U. First impression was that the sounds were mostly dental; does not seem smooth and even, but jerky and overdone; it is telling something in a poor way, or else something that is not very important. "Rastful hiz" brings up the idea of conflict. Some of the accents bother very much.

C. P. Explanation and reëxplanation all the way through; trying to change an opinion and get a change of attitude; yet it is quiet and intimate and neither profound nor very active; seems to be an appeal to the intellect rather than to the emotions.

D. P. Doesn't seem very peaceful or placid; there seems to be an extraordinary number of the "s," "z" and "t" sounds in it; the thing was so hard to say, that no attention could be given to the meaning.

F. P. Pleasant rhythm, but the content seems dry and wooden; the sounds flow together fairly well, but it has no color.

K. P. For the most part the sounds are rather cool and clear; at times a trace of melancholy enters in; the sounds are well arranged and the rhythm is uninterrupted.

L. U. "Horrid!" No melody to it; the sounds do not blend together, and no reaction comes at all.

M. P. At first it sounded "worked over" and not spontaneous, but afterwards it got to be a quiet little narrative, or a quiet talk; tries to be a little solemn at times, but soon lightens up and gets almost "pert."

P. N. Means absolutely nothing; some of the words tend to get respelled and mean something in English, German and French, but the organic strains accompanying the process take the focus of consciousness; "rastful hiz" ought to mean something.

S. N. Nothing suggested or aroused by it; got no imagery, nor was any sound prominent; it was just a thing to say, and he was glad to get through.

Browning, Experiment XIII

Is this apparent, when thou turnst to muse
Upon the scheme of earth and man in chief,
That admiration grows as knowledge grows?
If, in the morning of philosophy,
Ere aught had been recorded, nay perceived,
Thou, with the light now in thee, couldst have looked
On all earth's tenantry, from worm to bird,
Ere man, her last, appeared upon the stage—
Thou wouldst have seen them perfect, and deduced
The perfectness of others yet unseen.

Browning, Experiment XIV

Thĕ nûrnst ă pär ŭn skēē thăt wŏn ĕd rā
Shŭ lŏn ănt fẽrd ẽrz whĕm tōō chōrm thŏ mēēf
Jĕ zūme ĕnt thûr hăd lĭn rā wōze ĭn grĭs
Now yăm pẽr thŭl ĭf drēēp ĭz lä fĕct rĭn
Rē mōrd ow stā thĕm jŭd rā sēēl ŭp năd
Hẽr stăz ĭng lō fĕct mēē frŏm nĕss ĭn stŏŏn
Dē grā mī tĭth ănd pẽr thēē vī nĭf kawm
Thûr wăn thăp vĭd now kĕn thŏn dēēs thĕ năd
Tū dŏth hẽr nŏs ŏf bew pĕz tĕk ŏf nōōr
Thŭ dûrs thĕ tĕp hăv tŏn thou stĭb ŭp tŏs.

Browning XIV. (The transmogrification of XIII.)

A. U. Sounds somewhat descriptive, and somewhat philosophical; slightly remorseful feeling at times.

B. U. Not good poetry at all; too stilted and commonplace; may describe some strife or disconcerted state of mind; very hard to read, to say, and to tap; the first tonal impression was: "ssth." Yet the rhythm seems very good, even if the sounds are not smooth and mellow.

C. P. Some parts are smooth and others are rough; seems like one sound after another and nothing more; the kinaesthesis is very far forward.

D. U. The sounds jump around very irrationally; much impressed with the tonal inconsistency. No meaning could be possible in this passage.

F. U. Hard to say; wants to go on, but cannot; sounds like jumping from one stone to another across a brook; it doesn't flow at all; to say some of the sounds, *e.g.* "durz" gives him an awful pain in the nose.

K. U. Rhetorical and slightly melancholy; interesting because such a dreadful jumble of sounds; couldn't say it fast; feels as if he had bombarded his face with words.

L. U. It is some soliloquy, giving the pros and cons; doesn't excite, and is not important or profound.

M. U. It is not poetry; the pleasant sounds are in the minority; took all the attention to say it, and means nothing; seems like one hundred separate syllables.

P. P. Has no meaning, but goes rather easily; "her stazing," etc., ought to have some meaning, but it doesn't.

S. P . Seems calm and quiet, and draws some analogy between nature and human life; has just a touch of sadness in it; it is animistic, and psychologizes; at the end it seems not sad, but calm.

Marlowe, Experiment XIII

I will, with engines never exercised,
Conquer, sack, and utterly consume
Your cities and your golden palaces;
And with the flames that beat against the clouds,
Incense the heavens, and make the stars to melt,
As if they were the tears of Mahomet,
For hot consumption of his country's pride;
And till by vision or by speech I hear
Immortal Jove say, "Cease, my Tamburlane,"
I will persist, a terror to the world.

Marlowe, Experiment XIV

Ī sĭll thŭ nĕv yōōr kŏng ĕn zōōm thŭ wĕn
And flāzĕr tĕx thăt gŭld ĭn kloum ī zĕlt

Im dīle shŭn kō fōr mĕnst ăn gēēb hĭz lāne
Thŭ tămrĭz wĕr wĭth prĕnt ā stĕmbĕr sănz
Thā chēē tăl spōr ŭn rădz yōōr sĭnd hăz lāke
Tōō sĕm thŭ pärz ănd hō jĭnz wăv ĕr zēēr
A stĭth ŏv tōs bī vĭzh ā wĭmp tĕr zĕrld
Bûr kīde ĭz tĭf kĕr mōr năd sōō nă lĕns
Thŭ hĭv ĕrk tŏv sā jĭt pĕr wēēt rē tĕsk
Dō rŭt mī hēēs ŏb tā kŏn tŭs lī tăm.

Marlowe XIV. (The transmogrification of XIII.)

A. P. Thinks of something in connection with government or rulers, monarchies, or the like; very egoistical, and is a conversation describing something in utter pride; hard to say until this meaning became focal.

B. P. Predominantly dental; the rhythm is very good; no meaning except one of vigorous activity; thinks of something high and bleak, like a precipice and people near it; not liquid or labial enough to be the best kind of poetry.

C. P. Describes something, possibly; arouses some attitude of eagerness and slight forcefulness, and the kinaesthesis was very far forward in the mouth as if it was an oration.

D. U. It is rough, jerky, noisy and shallow, and gets worse at the end; seems very high pitch, and the "s" is too prominent; it is vigor without depth.

F. P. Has no harsh sounds, and flows well,—also better at the start than at the end; images some one reciting very loud, standing up, and railing at the social order of things.

K. U. The sounds get worse and worse and the whole thing is one emphatic drive from beginning to end; seemed ludicrous on this account.

L. U. Description of something, or else philosophizing, but has no emotional depth; more or less interesting as a collection of sounds, but there is not much to be gotten out of it.

M. U. It is hard work, not poetry; gets the idea that someone is digging away with a dull shovel, ten pounds of work to one ounce of earth; can manage the first five lines fairly well, but the rest has neither rhythm, nor beauty.

P. P. It means nothing, but the saying of it is a dreadful strain; tried to let some of it go freely and then he got all mixed up; and even when he tried to control it, it began to pull his arm like a ton of lead; had to go slow and rest while he said it.

S. P. Some passionate and disturbing person is "bluffing" in this poem; there is depicted passion, scorn and defiance.

Rank lists for the experiments numbered XIII and XIV, performed during the second year's work.

I. The Poems in English (XIII)

Subject	Keats	Byron	Arnold	Tennyson	Shelley	Milton	Wordsworth	Coleridge	Browning	Marlowe
I. Mean.										
A.	d	d	c	d	d	c	c	d	d	c
B.	c	c	d	c	b	d	d	c	b	b
C.	f	f	g	g	h	g	f	h	g	g
D	e	e	e	f	f	e	e	e	f	e
F.	g	g	f	e	g	f	g	f	h	f
K.	a	(throughout)								
L.	b	b	b	b	c	b	b	b	c	d
M.	h	h	h	h	e	h	h	g	e	h
P.	j	(throughout)								
S.	i	(throughout)								
II. M.V.										
A.	e	i	f	g	g	h	e	f	i	d
B.	f	d	e	f	f	f	f	e	d	e
C.	d	e	d	d	e	g	d	d	e	f
D	g	g	g	h	d	c	g	g	f	g
F.	c	c	b	c	c	e	c	b	c	c
K.	j	(throughout)								
L.	h	h	h	e	h	d	h	h	h	h
M.	i	f	i	i	i	i	i	i	g	i
P.	a	a	a	a	a	b	a	a	a	b
S.	b	b	c	b	b	a	b	c	b	a
III. Rnj.										
A.	g	h	f	h	i	i	h	i	h	g
B.	e	e	e	f	f	g	f	d	f	e
C.	d	c	c	c	d	d	d	e	e	d
D	c	d	d	d	b	c	c	a	c	c
F.	h	i	j	j	e	e	e	f	g	f
K.	j	g	i	g	g	h	g	h	j	i
L.	i	j	h	i	j	j	i	j	i	j
M.	f	f	g	e	h	f	j	g	d	h
P.	a	a	a	a	a	a	b	b	a	a
S.	b	b	b	b	c	b	a	c	a	b

II. The Transmogrifications

Subject	Keats	Byron	Arnold	Tennyson	Shelley	Milton	Wordsworth	Coleridge	Browning	Marlowe
I. Mean.										
A.	c	c	c	c	c	e	d	c	c	c
B.	d	d	d	d	e	d	c	d	d	d
C.	h	h	h	h	d	h	g	h	h	h
D	e	e	e	f	f	e	e	f	e	e
F.	g	g	f	e	g	g	f	g	g	g
K.	a	(throughout)								
L.	b	(throughout)								
M.	f	f	g	g	h	f	h	e	f	f
P.	j	(throughout)								
S.	i	(throughout)								

II. M.V.

A.	g	g	f	f	h	h	g	g	h	h
B.	d	f	d	d	g	c	d	f	g	g
C.	f	d	e	h	e	f	f	e	f	f
D	i	i	i	g	c	g	h	i	e	e
F.	c	c	c	c	d	d	b	c	c	c
K.	j (throughout)									
L.	e	e	g	e	f	e	e	d	d	d
M.	h	h	h	i	i	i	i	h	i	i
P.	a (throughout)									
S.	b	b	b	b	b	b	c	b	b	b

III. Rnj.

A.	f	i	i	j	h	b	i	j	i	g
B.	e	g	d	i	i	g	j	i	j	a
C.	b	f	f	h	j	e	d	c	g	i
D.	d	e	j	c	g	j	a	h	e	b
F.	h	b	g	f	c	c	b	f	a	f
K.	c	d	e	d	b	i	h	d	c	h
L.	j	h	c	e	a	d	g	g	h	d
M.	g	j	a	g	f	f	c	e	b	j
P.	a	a	b	b	d	a	e	a	d	e
S.	i	c	h	a	e	h	f	b	f	c

Correlations in Point of Vowel and Consonant Quality, Quantity and Periodicity

The rank lists for these experiments are the best we have yet obtained, for even those for the mean variation and the range show much steadiness of position for the various subjects. The correlation between feeling tone and motor discharge, however is of the same general type as we have obtained before; the unpleasant and the neutral experiments produce the longest tapped strokes, and usually, also, the Transmogrifications produce longer tappings than do the sources from which they were derived. This was also shown by the graphs for these experiments which may be considered somewhat in detail. They show exactly the same effects as the two first transmogrifications did,—that the explosive consonants and the short vowels produce a greater motor effect than do the liquids and the long vowels; take, for example the first four of these experiments performed, the Keats XIII and XIV, and the Byron XIII and XIV. The Keats XIV graph was higher than the Keats XIII, and the Byron XIV higher than the Byron XIII; the XIV's are also both longer than the XIII's. Now take another point into consideration: there are in the Keats XIV 23 short accented vowels, and 40 short unac-

cented vowels; 38 explosive accented and 22 explosive unaccented consonants. In the Byron XIV there are but 13 short accented vowels, 29 short unaccented vowels, 40 explosive accented and 18 explosive unaccented consonants. The conclusions are apparent and from the following lists of short vowels and explosive consonants in these twenty ten-line experiments, one can see the same tendency in all but two or three cases.

				Acc.	Unacc.
Arnold:	Short Acc. Vowels, 26;	Unacc., 40;	Explosive Cons.,	37	27
Tennyson:	Short Acc. Vowels, 17;	Unacc., 28;	Explosive Cons.,	30	18

And the Arnold experiments aroused more motor discharge than did those of Tennyson. Compare also Shelley and Marlowe, XIII and XIV:

				Acc.	Unacc.
Marlowe:	Short Acc. Vowels, 28;	Unacc., 26;	Explosive Cons.,	32	16
Shelley:	Short Acc. Vowels, 22;	Unacc., 38;	Explosive Cons.,	36	16

The graphs for these experiments showed clearly again that the motor discharge is dependent upon these sounds, and just as these two poets are nearly equal in the number of them they employ, so are the graphs almost equal in height and other features.

Likewise with Wordsworth and Coleridge; the graphs are nearly equal in height and so are the determining sounds in number.

				Acc.	Unacc.
Wordsworth:	Short Acc. Vowels, 24;	Unacc., 36;	Explosive Cons.,	31	21
Coleridge:	Short Acc. Vowels, 24;	Unacc., 35;	Explosive Cons.,	34	24

Milton and Browning do not show the same sort of correlation in this respect as do the other poets; the graphs showed this very clearly; the unlyrical subject matter of the Browning XIII experiment and the general negative character of the effect of the transmogrification bring again into prominence the introspective side of the experiment.

Insofar as any validity can be attached to the results thus obtained, it appears that the accented syllables alone are not in all cases sufficient to account for the increase of motor output caused by one line or one passage of poetry over that of another. Construed in their psycho-motor effects, either syllable, the ac-

cented or the unaccented, can be the cause of heightened motor manifestation. To this effect, then, we ally the results of our previous investigation in regard to the length of the "long" vowels: in both cases it appears that the intentional prolongation of a letter or syllable in consciousness is one thing, and the reverberant effect of such prolongation is another. In such cases one can at least catch a curious glimpse of the functional nature of some phases of the introspective and motor consciousness in their overlapping parts in point of the qualitative distinctions to be made between quantitative similars which only an analysis from the twofold standpoint of psycho-motor manifestations would break up out of a subtle fusion.

Mention must be made again of the form-quality of the graphs for these first long experiments. Just as characteristic differences had occurred in the graphs for the single lines of each of the poets, so here the XIII experiment for any poet produced a graph which had individuality as contrasted with the XIII of any other poet. Likewise with the XIV experiments. Those passages, whether XIII or XIV which had gone easily and smoothly in the recitation also went smoothly in the motor consciousness and the dip of the graph line from first to fifth foot was more marked than in those poets which produced other than the above mentioned effects. In every case the motor display and the introspectional flow showed what at least by analogy might be called common parts. Not strange, of course, since by this time the motor pattern of consciousness on the voluntary movement side was now paralleled by the apperceiving tendencies of the reading and speaking consciousness.

In many cases by actual counting of the accented and unaccented vowels and consonants, it was not easy to see why some of the introspective and motor effects were produced. Frequently the very look of the page, before an attempt to read it had been made, would suddenly "set" the motor tendencies in a very definite way, while the results of this "setting" would conflict with the auditory side of consciousness at the termination of the experiment. And so we had the conflict of such things as the fusion of subliminal stimuli for the read-

ing consciousness with the fusion of liminal stimuli in the auditory consciousness, and the like; here, also, the position of letters in the line, and the periodic recurrence of a letter as seen, but neglected in the speaking consciousness, or of sounds possibly unpleasant *quâ* sounds, but affording no displeasure on the side of visual form, entered as rather incalculable disturbances throughout the whole run of these larger experiments. That they could have been made constants, rather than variables, however, lies well within reason, had the experiments been conducted as a slow, inexorable arithmetic of spoken sounds, rather than as an esthetico-psychological investigation. In this connection it is significant to remark that the subjects took an entirely different attitude toward large passages, from what they did toward single iambic syllables, repeated to the point of tedium.

This ended the experimental work for the second year. We had performed 336 single-line experiments and 20 ten-line experiments and the results have been all given in the preceding pages. On the whole, the results are clear; from the numerical results of the 128,000 tapped strokes made during this year's work we have obtained proof that the unpleasant and neutral states of mind are correlated with a greater motor output than are the pleasant states; from the introspection on the vowels and consonant experiments we have been able to make statements about the effective and affective values of the various classes of letter sounds; while from the transmogrifications of the large passages of poetry we have been able to conclude that the sounds of poetry, especially lyric poetry, are able of themselves to arouse a mood congruous to that mood which the normal recitation of the original poem would arouse. This is exactly in line with the notion, on the basis of which the original thesis was made: the sensational element in poetry that is derived from the sounds themselves is immense,—poetry is largely tonal,—and it is certain, conversely speaking, that those poets which neglect the finer sounds of the language either deliberately or otherwise deny themselves a hearing that is worthy of cultivation.

THE TRANSMOGRIFICATION OF OTHER THAN BLANK VERSE INTO TEN-LINE PASSAGES

Only five subjects took part in the third year's work. With one exception, the experiments were all transmogrifications of other than passages of blank verse poetry. This exception was Shakespeare XIII. No suitable passage had been found during the first two years of the work, and this was the cause of the delay. The numbers attached to the third year's experiments mean as follows: XV means a passage of poetry, not blank verse, transmogrified,—usually a passage in decasyllabic lines; further experiments, numbered XVI, etc., means usually a passage of shorter than decasyllabic verse.

These poems were not very successful in the experiment. In the first place, rhyme is an encumbrance to the transmogrifier,—it makes alliteration almost a necessity, if one is to transmogrify line for line or keep the first lines of the poem in the first lines of his construction; in the second place, short-lined poetry does not have enough tonal body, usually, to be satisfactorily transmogrified into the heavier decasyllabic lines; there is something solid about iambic pentameter which must be maintained in order to keep the effect serious and dignified.

We next give the introspection of the third year's experimentation, and after that, a résumé of the numerical results and the correlations on the basis of feeling tone and motor discharge.

Keats, Experiment XV

Second transmogrification of "I stood tiptoe upon a little hill."

Ī hŏn tle tō thŭ ĭl tĭp stĕr bĭ vĭt
Sō lŏŏd ĭng prănd ŭp kīde ĕst mŏd ŭ thĭl
Wĭth ŭdz ĭn bōōl wŭz dränt ĭng stĕrv thŭ slăre
A lĭs ĭng kīde ŭ lāpe lī chĭst ŏv whĕmz
And fănt ĕr tōōp rĭ whĕmz ēēt sōrn lĭ nēēvd
Pŭl ŏst ă lăt thāre dĭn yĕt thŏb thŭ där
Frōm fī lĭ kŏv thē ĕpt hăd mawt thŭ tŏst
Az eur thōze klŏrn ănd flowdz thāre pīte neu slēre
Thŭ brŏx lĭ frŏŏk swănd krĕsh frŏm skēte eu swĕn
Blănd ĕv rĭngz klĕr thā hĕpt wĕr shŏn thŭ ēēldz.

This passage contains the first fifty accented and the first fifty unaccented syllables of the poem from which it was taken.

INTROSPECTION

B. P. Flows well, and the rhythm is regular and satisfactory; seems to be telling some tale, perhaps slightly epical in nature. Upon reading it a second time, got imagery of a shore and a chivalric or romantic scene; the setting may be slightly sexual in its significance.

F. P. The most pleasant lines are Nos. 6 and 11; makes him think of Anglo Saxon poetry; imagery of an open air scene, with sunshine and flowers; some of the sounds appear remarkably strong for such a description.

K. P. Sounds a little mysterious and melancholy; thinks of English country scenery in the fall of the year,—certainly not in the winter; rather warm, tonally, but not at all deep; felt the pitch to sink a trifle toward the end; surprised that it went even as well as it did; kinaesthesis not noticed.

L. P. Recalls the days of chivalry, and thinks of King Arthur; gives a thrill in the breast to read it, and it all goes very smoothly; felt the accent to be very prominent and expressive; it sounds familiar, but he cannot tell when or where he has seen it before.

M. P. Seems very long; at first the imagery was that of a ship and the sound of the water and the calls of the sailors, but later it changed to a more subtle, and very delicate thing like some romantic scene and idle and care-free people; the consciousness was a sound-consciousness entirely, with the exception of fleeting visual imagery, and the tapping was forgotten entirely.

BYRON, EXPERIMENT XV

The transmogrification of the "Apostrophe to the Ocean," beginning with "There is a pleasure in the pathless woods," and ending with the fiftieth accented and the fiftieth unaccented syllable.

Thŭ plāre lĕss wĭn ĭz ăth ōōr lōōdz ŭ pĕzh
Ū rŏn tūre thāre lī nōre thŭ păsh ĭz trōne
Sō thŏn whāre ōōdz ĭn sī ĭz thāre zĭk rĭn
And meu dĭts bī thŭ nōre tēpe lăn ĕ sē
Nī mŭv thŭ whā frĭn ēēl tēr chĭm bŭt lōr
Ī stĭn thŏt mēēz ŭre thĕs our fĭng bē väll
Ī prăn thŭ wĭn gle nĭth ŏt ōr kŏn sōō
And kēs tōō yāre kĕt äll rĕx tĭd ŏm dō
Lōō bēle ăn kär yōle Ī nŏt ŏn bănd ēpe.

Introspection

B. P. From the n-drone the passage contains he gets the idea of a forest and ocean scene, rather peaceful, languid and quiet; it may be that some one is philosophizing or lecturing on contentment; quite a lot of sibilants in the passage and frequently "v" and "f," also the liquids.

F. P. Had quite a good deal of difficulty in saying it; and doesn't feel that the ending is satisfactory at all; but the passage is strong and vigorous, with a sort of latent strength and it gives him the idea of something semi-heroic. The staccato effect of "k" is noticed frequently.

K. P. Gets a vivid image of the sea-shore on a cool day; melancholy enters into the whole concept, which is not gotten by any association, but by a direct evocation from the sounds; thinks the passage is homogenous in sound effects, and ability to call up these images and notions.

L. U. (Subject slightly weary.) Nearly every line contains some objectionable sound; "epe" in the last line does not end the passage properly (this passage was presented again later to the same subject, he remembered not having liked it and the experiment was not a success.)

M. P. Imagery of a meadow enveloped by a mid-summer mist; slightly chilly feeling accompanied the imagery; the saying of the lines was rather difficult, and this took all the attention.

Gray, Experiment XV

Transmogrification of the first fifty accented and unaccented syllables of the "Elegy."

Thŭ närt ĭng kĕl ŏv pẽr thŭ dōlĭ slē
Thŭ lẽrd ăn ā fĭng plō thŭ tā mănd plōr
Hĭz ŏm rĭ wē zīned ōlz eu mŏdz thŭ wē
Tōō low nĕs wärk tōō ẽrld thŭ land ẽrd dēvez
Thŭ hĭmmĕr glīte wĭng lādez ănd hĭl zow fŏn
Pā stŏl mĕn dōlez thŭ säll nĕs ănd thŭ sāre
Hĭz bāv ĭng sŏntle whē thŭ tī wāre drēēlz
Thŭ sĭddănt drow lĭsk tŭl tĭngz flāve ăt klĭn
Whăn yōldz frŏm hŏntled mour vĭ mowlĭng tāne
Thŭ pō kŏm dīfe thŭ săn tū mŭz dẽr plōōn.

Introspection

B. P. Describes something that happened long ago and gives a feeling of content, rest and solace; imagery of romantic country scenery, and now and then sees an old man moving, but not vigorously; very rich imagery and he becomes totally empathic to the scene. The sounds seemed at first rough, but afterwards smoothed down very much.

F. P. Arouses a sober mood, in spite of the fact that the sounds now and

then are dreadfully turgid; gets visual imagery of the outdoors, but it is not very clear.

K. P. Seems hard to say; a very definite mood seems to be latent in it; thinks of the fall of the year and the woods, and now and then a trace of melancholy enters into it; now and then he thought of summer instead of the fall, but it changed again and ended in the latter season.

L. U. Certainly it is not dramatic; it sounds rather sleepy and ineffective (subject does not greatly care for Elegy); got no imagery and did not find it easy to say; calls it "inconsequential."

M. U. It "looks" bad, and is hard to say; too many "z" sounds in it, but cannot tell why; gets ideas of lazy people and stupid foreigners,—people that are not up and doing (this kind of human beings are "persona non grata" to subject M).

Browning, Experiment XV

Transmogrification of of "Rabbi Ben Ezra," lines 1 to 13½.

Thŭ jōld ă mēst ĭz bŏng wŭz ĕt wō bē
Tōō lērst ŏv whāde thŭ fē grĭth īfe thŭ chīm
Fōr hĭn ĭz tast ī lĕth är plīmz ă gē
Hŏō frōle ŭst whāde our shănd ōōth săf ē bōze
Yā näll trĭng flŏd thăt hăs bŭt mănd ĭch rēēv
Rē nowrz hā bōze ĭch mŏt ĭs kĕn mănd thĭl
Nōr ĕst whāke säll trăz līde ŏm jŏt sĭng mowrz
It lärz whĕm hŏv thăt mērnd ōōth stīre whĭch flĕndz
Bē mā theurd sĭg yăn blärz nōr fĕndz ăd näll
Nōr hī chănd nōpes ŭs tŏf ŏv nŭl făn zēēr.

Introspection

B. P. Seems fairly rhythmic and easy; kinaesthesis is everywhere in the mouth; evokes a mood of matter of fact pessimism; thinks of some middle-aged person, some pseudo-philosopher advising a younger person; is sophisticated, disillusioned and resigned.

F. P. Sort of humorously eloquent; almost physically ticklish; now and then a slightly tragical feeling, but laughed at it; the sounds are very Swedish, it seems, and the whole thing attempts pathos, but ends up with bathos.

K. U. Blundered through the whole thing, and calls it a tonal and poetical blunder; rather rhetorical in spots, but again positively full of humor; something "citified" about it, too conscious, too sophistical; it is "speechifying" more than anything else; takes a lot of energy and is full of irregularities.

L. P. Rather dramatic, but has no meaning; sounds like Gaelic or Welsh; may be recounting some tale.

M. P. Sort of a joke; interesting and very light; not hard to read; it is

not important, but it goes well; full of spirit, and sounds a little condescending and amiably superior at times, but she could not take it seriously at all; (laughed much).

TENNYSON, EXPERIMENT XV

Transmogrification of "Crossing the Bar," with the most used sounds in the poem repeated to fill out the last few iambics.

Thŭ wŏn ĭng tēēv ĕn boun ăz plā năd kẽrnz
Tōō rawl nĕt bēme ĕs nōve ănd bärlīng mēēz
Fōr nŭs whĕn stäm whĭch krāme thŭ bīde ŭs fō
And tow bŭt flōn ĭng twī nĕs mŏb rō slēme
Whĕn fûr mā lē pŭt chăd ĭng rābe thŭ närk
Fōr sōō năy drĕl tẽr gäm thŭ hō năd wī
Thār bēēs ă tow frŏm ē lănd tēpe ă dŏv
Klā dăs mē thī fōr dăv ō lound thŭ tē
Whĕn tăf īte bĕm tōō sŭd thār tow frĕn sōō
Fōr mĕth ŏm tīse ănd pō năd ŭv rē thā.

INTROSPECTION

B. P. Easy to say and produces a feeling of apprehension; never got exactly into it, and the imagery and emotions were indefinite; (subject pondered the passage quite a while after the experiment, but no further introspection was obtained); kinaesthesis is felt on the lips mostly.

F. N. Rather easy to say, and there is a good deal of openness about the sounds, but no imagery came; feels often that the unaccented vowels ought not to be long.

K. P. It is very temperamental, and at times slightly melancholy; thinks of ploughed ground and gets ever olfactory imagery; but there is also a slight monotony (sameness) about it, and at the end there came a feeling of something like listlessness.

L. P. It's very nice, but does not provoke a big reaction; seems to be describing a sad and tragic event; probably the death of a certain person; thinks of many perils, enemies, trepidation and the like. The sounds are wonderfully good.

M. P. Rather easy to say, and line 7 is charming; doesn't seem very serious and makes one think of the sounds of nature; gets imagery of the woods, fields and the like; but the whole effect is quite steady and self-contained.

ARNOLD, EXPERIMENT XV

Transmogrification of "Dover Beach," employing the first eleven lines and a part of the twelfth.

Thŭ näm ĭz dīle ănd strā lănd sŏn tĕr vē
Rō nāre thŭ tŏn quĭl bīne thŭ sĕng ŏv mĕrn
Whār kĭnd ĭng sprēēm thŭ stäl chĕn tīfe ĭz kō
Thŭ gŏn frĭn lĭs ŏv stăm blez nāre thŭ chēē
Tū flĭs thŭ whēē năd zĭl thŭ hûr dŭm thĕn
Thŭ sē drăn wāpe eu'towm ăt stĭn ŏv nōōm
Thŭ tī frŏl wēte thŭ bāfe ŭp tōle thŭ grĭs
Chī păng thŭ stābe ĭng krănd hī thăl thŭ gĭnd
Tū stōōn thŭ trăf ĭz glāke lī kŏs bē swēēmz
Blăn ōr hĭz rōōn daw nōle thŭ glĭ mĕn zāve.

INTROSPECTION

B. U. Traces of pleasantness in the first part, but at the end it was rather sarcastic, *i.e.* full of a sort of "Schadenfreude." Too many "s" and "z" sounds in it, and too many unusual sound combinations; the first six lines are better poetical constructions than the last four; tried to like it, but the kinaesthetic factor dominated.

F. U. The first line is not so bad, but the rest are horrible, and he does not think there can be any such sounds in poetry; a lot of the words give him pains in the face, such as "glake," "gind," "gris," etc.

K. P. Got a very distinct feeling of standing up and "giving it to some one" in a rhetorical manner; there is a great deal of reserve strength in it, and the pronunciation is very prominent; not moody, like some of the others, but rather stern and a trifle polemical.

L. P. It's tragic; thinks of a combat; there seems to be something dramatic, moving and forceful about it; visualizes a storm at sea, through which the vessel finally rode to safety. This was due to the associational element in the sound themselves.

M. P. At first it was very heavy and labored, and did not delight her soul; then it became better, and visual imagery of the sea with people talking in a dignified and probably hushed manner about it.

SHEKESPEARE, EXPERIMENT XV

Transmogrification of the LXIVth sonnet, lines 1 to 10.

Thŭ rēne hŏv kī whĕn fŏst hăv bīmz ĕl tāje
Dē rănd ōrn tē prĭd lāste ăn sĕr boud mowrz
Whī tāzed ĭt răs woun slāje ăl chĭs ănd vōre
Nē brī tōō sŏf dăl mŏs thŭ tow grĭ hāv
Fĕn gĕr tăv sō mī hēēn ăd shăn ĭj tā
Tī kŏs ŭn woil thŭ tŏs ŏm dĭng thŭ wănd
Hŏv stĭnd ĭng kŏv ĕrm āne thŭ lŏn tĕr krēēs

Whĭn ōr thŭ stŭn ĭth chēēm ănd nĭs fŏn ōr
Dē fānj whĕn tōō wĭth stā kăv ī wĭt stoun
Wĭth tā chŭs ōr shĕd mĕlf ōr lŏs tĕr nā.

Introspection

B. P. Has much emotional value, and there seems to be a sexual element running through it; but very rich and refined, even if voluptuous, and it might be taken from a poem which contains a sex-philosophy of life; the lip sounds and the "j" and "ch" sounds are particularly predominant.

F. P. Means nothing to him and the pleasure is in the rhythm only, "j,' "ch," and "sh' sounds quite prominent.

K. P. Seems to be of low pitch and is slightly provocative of melancholy; visualizes a market-place full of people; the mood is not depressing, but the kind of a melancholy that one takes delight in. "De rand orn' is very fine tonally.

L. P. Very nice and smooth; narrative and not dramatic; is like Shakespeare in Othello where the story of the ships being lost is narrated (? query, Merchant of Venice). Got no imagery, but tried to.

M. U. Very doleful and depressing; recalls the "Flying Dutchman," and all the attendant weirdness of it; it is minor music all through; at the second reading, it got insistently pathetic as in describing a great loss that was irreparable.

Wordsworth, Experiment XV

Transmogrification of the opening lines of the "Ode on the Intimations of Immortality." Employing the first fifty accented and unaccented sounds.

Thŭ strēē bĕl grāme ĭt vō nĕs mĕr năd lē
Whĕn glī năd vāre chŭl păr mŏn thĕl rĭ dĕm
Tōō mĭn dĭd nōre păs tĭngz ĕrn drēē wō nēse
Ī trō vĕrz kŏm thŭ shĕmz ō wĕn dŭth rā
Dē nowd ŏv kŏm ī tēse thŭ mā lĭ zōre
Whī nā chănd thī lŭz frĕm hĕr tow krĭ sāre
Ath yōme thŭ rĭs hăv zēē năz dow thŭ tīne
Ōr whĭnz ŭ tābe sō bĕth ŏt hī năd wĭt
Kēē vär nōōt whī thŭ zēn ăd sĭl bō nĭth
Dē gōze är vŭl hăn dīze thŭ nōōm ă när.

Introspection

B. N. Seems rather matter of fact; not what he calls poetry, because it is rather narrative and epical, not lyric and free; seemed easy enough to learn

to say it, and the kinaesthesis is forward; the "z," "s," "d," "th," and "t" sound prominent.

F. P. Rather hard to say; calls it "Kammersprache," rather than poetry; the sensations aroused are akin to those experienced while walking over a muddy, frozen ground. No imagery.

K. P. Arouses melancholy at once; visualizes an English moor, over which he seems to be walking; obscure feeling all the way through, as if hesitating to say or do something; the prominent sound is the "wh."

L. P. Only a very slight organic quiver aroused by the poem; it is barbaric, but enjoyable; thought of Norsemen by association, and also of the Goths. The feelings are rather lukewarm.

M. P. Images a cliff overlooking the sea and of someone on the cliff telling tales of the sea; it is very appealing and peculiar; thought there were many full cadences in the poem. At times it became very confidential.

Shelley, Experiment XV

Transmogrification of the first fifty accented and unaccented syllables of the "Stanzas written in dejection, near Naples."

Thŭ märn ĭs wērĭng klāve ŭn wīle ĕd zāre
Wĭth sănt ĕnz brĕm thŭ tound ĭt pār thŭ skō
A wĭn ĭz nōōm ĕld voin ī sŭl ĭts brēē
Thŭ nĕlf ĭz pĕr shŭn zīt ĕnt rast thŭ vound.
Trĭ lō brănd shŏn ī pănd thŭ grē lŏv sĕrth
Dē moidz ĭt nŭs thŭ swĕn lĕx mĕrdz ŭp tīse
And stēē kär sŏth ī bĭndz lī tois thŭ dŏft
Zăn ēēps ĭz pĕrn ĭk fēēs ŭp strŏn thŭ trōve
Zē păm thŭ flōōdz wĭ bōrs pŭl tī wŭd lĭs
Thŭ wŭz ŏv tŏs ī zŭd lū flāves ĕd wī.

Introspection

B. P. Gets imagery of the sea and the splash of the surf at once; seems very onomatopoetic; and in spite of the fact that there is much "s" and "z" in it, it is pleasant, but by virtue of the imagery only; gives a vague feeling of uneasiness and there are many bodily tensions.

F. P. Rather moody and sombre feeling aroused by it; there is much mouth movement and one has to slide to some of the words and stop hesitatingly before others of them; feels tense, not on account of the pronunciation wholly, but on account of the mood.

K. P. Feels as if he is reading a somewhat morbid fairy story, and the emotion is one of mystery and helplessness; this comes direct, and is not associational at all; at first there was a feeling of withdrawing from the mood, but this soon ceased; it seems to be bound up in the sounds themselves

and in nothing else; the frequency of the long vowels being unaccented seems to heighten the power of the poem to sustain its mood.

L. N. The sounds are good, but he cannot feel the connection between them; now and then it seemed as if the whole thing would get unified, but it never did.

M. U. Very depressing and disappointing; arouses a mood in which one feels helpless; so many interesting sounds in it, like "gree lov serth," etc. The first five lines are cheerful enough, but the last five are doleful.

Cowper, Experiment XV

Transmogrification of the well known lines: "Knowledge and wisdom, far from being one," etc. (This was selected, not as poetry, especially, but as a test of whether the transmogrification of a didactic, homiletic poem would be successful.)

Hăv nŏl ĭng bär dŏm fŏn ĭj wēēn ŏm ĕlz
And ŏl frŏn wĕk ĭth nŏft ĕr nĭz rē dwĕn
Kĭn plō dĭj mäwts ŏv thēēt wŭn hŭth īmz ōr
Shŏm wĕn tĭn mĭz thăt rōne tĭv zēde mā tīnds
Thŭ prăs ĭj mŏf ĭch tōō năd zōme ĭts bōōd
Ā wēre ălz tāse ĭl smāred ŭn tĭz ĭt plēre
And wĭth ŏm dōōth whār zĭld ĕn fŏl ble chĭm
Dĭz bōō thăt rowd nō prĭt ŭs kĕrnd ŏm squē
Sō lŭt hăz whēēmz ĭt chŭmbĕr năt ĭz hōōm
Hē sŭmble nĭz dĕd wŭth ĕn hŭm dĭz nŏl.

Introspection

B. P. The prominent sound elements are the "n-drone," the dentals and the labials; got no imagery and no meaning; commonplace.

F. P. Very queer thing; full of pauses, and the rhythm feels like the different steps in a fancy dance; besides the rhythm, there is not much to it; as far as meaning is concerned, it sounds like optimistic speech-making.

K. U. Seems cool, emotionally; rather rhetorical and arouses no imagery; in spite of its poverty of emotion, and its unpleasantness, it is interesting.

L. N. It is not dramatical, deep, or poetical; it's like Pope.

M. P. Amusing; like some moral story to be told to youngsters; line 1 starts out grand and almost epical, and then the whole thing tumbles and never regains itself till the end.

Dryden, Experiment XV

Transmogrification of lines 94 to 103 inclusive, of "Absalom and Achitophel."

Dē mŏv ēr prănd ŏm däll ĭsht ăz hĭm pīved
And lŭb ĕz tĕsh är flănd ŏv lŏŏd ŭz blärd
Kā hŏst wēr yăx ănd grĕt thār wănd ĕld bŏdz
Tōō gērnt ŏn stŏm thĭs kā thīke sŏŏd thār whāme
Dăl prŏt ŏŏd ĭn thĕn flĕt thŭ hē mĭs präll
And sär thŭ stēē thŭnz jĭl ŏv mā fōr stēēs
Rē bŏd sō rēse thār hĕnt ŏv hĭz dē gōme
Lī grŭth ōr whēē bŏŏd pōne ŏk stĕnz ĭn sär
Hăz dōle thŭ fēēb ĕn gät hĭs ōrn stĭn tēēb
Hŏv ĕd ănts ĭf hē hăd ĭz bēr vā dōle.

INTROSPECTION

B. P. Predominantly dental; seemed rather easy to learn; quite matter of fact and denotes activity of a non-poetic character; some people are doing something,—all the way from arguing to moving vigorously about.

F. N. Very unpleasant caesural pauses; very heavy and clumsy, and cannot be lyric poetry, nor written by any one who knew the musical value of sounds; tried to get away from it and couldn't.

K. P. (Laughed.) Humorous and countrified; seems to be telling some "yarn,"—a good big one; the speaker is perfectly willing to hear himself talk; tonally, it is just an interesting collection of noises.

L. N. Got no reaction from it at all; it never drew his attention fully and he began to think of other things.

M. U. Feels like going over a rocky road; felt no rhythmical swing except at "hiz de gome"; no imagery.

DRYDEN, EXPERIMENT XVI

Transmogrification of lines 66 to 78 of "Alexander's Feast."

Thŭ vound ĭth hāne hĭz dōōth ănd ōr gră säll
Fōō nābe thŭ gĭng ĕd slantĕlz tāse hē kōze
And thrăsĭng fōō thŭ räll ĭz townĕss răd
Thŭ mīze ănd släwmĕnt glōtēr chīze thŭ fēv
Äwt thrīde hĭz kēēs ĕn sär wē hīle dĭz thēr
Hĕn frīse ĕn pränd hĭz chōrn ĭz mew hē dānj
And tĕk ĭs chī hĭn däll ŏft whēēr fŭl zōme
Hē tewz ĕn chäll ē zŏŏd ănd fīse hē tāfe
Dī hŏn hĭz rĭt ănd tā dē sŏŏf hă gräll
En pīfe ŭs tā sē fŭng bā stīge ă tōōve.

INTROSPECTION

B. P. (?) Hard to say; the "s' and "z" sounds predominate, and somehow make it sound gummy; feels that the cheeks have moved a great deal; hissing

and breathing is frequent; it is both difficult and amusing, and he cannot get any meaning out of it.

F. P. Thinks of trotting horses and movement in the open air; but this he holds to be due to a direct association from the words "soof" (= hoof?) and "ritand" (= reiten [Ger.] which he pronounced with a long "I"). Goes easily and quickly.

K. P. Very smooth and interesting; gets a cobwebby mood of mystery, but doesn't know why; feels that many of the expressions in such a passage will turn into words, if one looks for words.

L. N. Gets no reaction whatever. (N.B.—Between this and the previous passage experimented upon, Subject L. relieved his mind of certain matters which were annoying him, but not even then did any reaction to the above poem take place.)

M. U. Dislikes the looks of it; it sounds blatant and impudent and is full of the most difficult combinations possible.

Spenser, Experiment XV

Transmogrification of Stanza 34, Canto I, "The Faery Queene," with the most used sounds repeated to complete the last line.

In läz ĭt wĕrtle hō mĭ lĭt ă tāje
Lĭ fīde ă sown ăs därd ŏv ōr ĕst ēde
Rē hāle ĭd zär dŏm tōrple tăth ăl făs
El păv ă tĭl bī frōtle wōō thĕl dīte
Thŭ trōtle fīde är wĭn lĭ hăz ĭ chĕr
Tōō mĭngz ĭt hāde lĭ sŏnt är tew frĕn dē
And bīde lĭ pōrn hĭz krā chă wĭs tăl păj
Thăt wēēm ĭd hō dĕn lĭt ā fŏm ĕd plī
Chī thōr lĭ frĕnt whä thā krē toun lĭ wāse
Whā lō mĭ pĕr năd fĕv ĕd strĕl ĭn tāje.

Introspection

B. P. The vowels seems very predominant; the dental consonants rather numerous also; very poetical substance in it, but cannot get at it; upon a second reading notices the liquids more than the dentals, and the sounds seem very open, but this does not make it at all oratorical,—rather quiet and restful, instead.

F. P. The lines containing the words that end with "tle" remind him of Maeterlinck's "Blue Bird"; direct association; some of it very easy to say and some of it very hard; wonders what the frequent repetition of the word "taje" means.

K. P. Easy to say; not exactly melancholy, but something very akin to it; no content suggested, just this strange feeling of artistic melancholy.

L. P. Excellent Jabberwocky; got a rippling feeling down the back;

doesn't seem to be anything very tragic and vital; just like some nice little quiet talk.

M. P. The words ending in "tle" are at first very quieting; then the "look" of the letter "j" annoys and seems to color the whole thing; would become unpleasant upon very slight provocation.

Shakespeare, Experiment XIII

Shall I believe
That unsubstantial death is amorous,
And that the lean abhorred monster keeps
Thee here in dark to be his paramour?
For fear of that, I still will stay with thee:
And never from this palace of dim night
Depart again: here, here, will I remain
With worms that are thy chambermaids; O here
Will I set up my everlasting rest,
And shake the yoke of inauspicious stars
From this world-wearied flesh.

Shakespeare, Experiment XIV

Thŭ lăn săl dē shẽr năn ăt rŭs ăb stĕn
Iz kīn ŭl mēēps ănd hăn bē mōr sŭb lĭth
In thēēr shă dăl hĭz pär thĕd bŏth ĭl stōōr
And ēēp thŏv hāne tōō stăl fẽr tŏv īth rēēsp
Stī fĕv ōr nŏm ĭs gēē fŭl wĕn dē thīte
Wẽr pĕm dăs hāne ă chī wē lä wĭl frēēr
Bō mā thẽr zŭd ĭm spär thăt hī wĭth pāme
Rē shẽr ĭng tĕv ĕt räst thŭ kā wēēr flŭn
Mī lĕs ănd wēēr ŏv kō thẽr yăst ĭd rēēsh
Hī zär mōld sĭth aw rĭk wẽr zĭm ŭs rēēt.

Shakespeare, Experiment XIV. Transmogrification of XIII

Introspection

B. P. The sibilants do not disturb, although they are very numerous; gets visual imagery of the woods and the sea; the general aspect is quiet and solemn; seems restrained and hushed; no activity in the notion aroused,—can hardly tell what it is.

F. P. Seems delicate and soft, with only a few interruptions such as "reesp"; rhythm is both quickened and slowed in places, and he rather likes the necessity to stop and begin again at a different tempo; feels like the resolution of dissonances, every time it occurs, which is usually after a difficult word, or one that causes readjustment of the vocal organs afterwards.

K. P. Smooth and easy to say; doesn't get any definite imagery, but the general effect produced is rather subdued; thinks of either a calm on the sea, or a suspense of activity; the thing has a lot of meaning, but it is very subtle, and for him, latent.

L. P. Not epic, but lyric; seems pastoral, rather than anything else; the opening lines reminded him of the tonal effect of Gray's Elegy.

M. P. Would not have been surprised to have heard an organ keep up the tonal effect after the end of the passage came; there is a rumble of heavy, grand tones underneath, as it were, the sounds as spoken; it is not the rhythm that is the prominent feature, but the sound-mass, which is surprisingly new and agreeable.

We have omitted from this list a small number of experiments made after the same pattern: Coleridge's "Christabel" was tried, but proved introspectively unsuccessful; likewise three songs from Shakespeare made over into five-line passages,—"Hark, hark, the lark," Ariel's Song, and the Boy's Song from "Measure for Measure." Likewise two passages from Swinburne's "Laus Veneris," two from Rossetti's "Blessed Damosel," and one of Sydney's Sonnets. Jonson's "Drink to me only with thine eyes" as well as a passage from Pope's "Essay on Man" fell flat.

The writer usually found it more difficult to transmogrify the shorter verse forms into decasyllabic lines than the others. Tonal replicas were less easily elicited from such passages, which having been cast into a form tonally demanding other than the decasyllabic pattern, remained recalcitrant to the pulverizing and agglutinizing process of this experimental method. Soft as the tonal data of poetry may be, yet it would appear that the various form-orders of verse lie not in intersecting series.

Rank Lists for the Experiments Performed During the Third Year's Work

I. Mean Subject	Keats XV	Byron XV	Gray XV	Coleridge XV	Browning XV	Tennyson XV	Shakespeare XVI	Arnold XV	Shakespeare XVIII	Shakespeare XV	Wordsworth XV	Shakespeare XVII	Shelley XV
B.	c	c	d	e	c	d	c	c	b	b	c	c	e
F.	e	e	c	d	e	e	d	d	d	d	d	d	c
K.	a (throughout)												
L.	b	b	b	b	b	b	b	b	c	c	b	b	b
M.	d	d	e	c	d	c	c	e	e	e	e	e	d

	Cowper XV	Swinburne XV	Rossetti XV	Rossetti XVI	Dryden XV	Dryden XVI	Swinburne XVI	Spenser XV	Sydney XV	Jonson XV	Pope XV	Shakespeare XIII	Shakespeare XIV
B.	c	b	c	c	d	c	d	c	c	e	d	c	c
F.	d	d	e	d	c	d	c	d	d	c	e	e	e
K.	a	(throughout)											
L.	b	c	b	b	b	b	b	b	b	b	b	b	b
M.	e	e	d	e	e	e	e	e	e	d	c	d	e

II. M.V. Subject	Keats XV	Byron XV	Gray XV	Coleridge XV	Browning XV	Tennyson XV	Shakespeare XVI	Arnold XV	Shakespeare XVIII	Shakespeare XV	Wordsworth XV	Shakespeare XVII	Shelley XV
B.	b	b	a	a	a	d	c	d	e	a	a	e	b
F.	a	e	b	d	e	b	d	c	b	e	c	a	a
K.	e	a	c	b	d	c	b	a	d	c	b	d	d
L.	d	c	d	c	c	a	a	b	c	b	d	c	e
M.	c	d	e	e	b	e	e	e	a	d	e	b	c

	Cowper XV	Swinburne XV	Rossetti XV	Rossetti XVI	Dryden XV	Dryden XVI	Swinburne XVI	Spenser XV	Sydney XV	Jonson XV	Pope XV	Shakespeare XIII	Shakespeare XIV
B.	b	e	c	e	a	d	c	e	b	c	b	c	b
F.	a	c	a	a	b	c	b	b	c	a	c	b	d
K.	e	a	e	c	e	b	d	c	a	d	e	e	e
L.	d	b	d	b	d	a	a	a	e	b	d	d	a
M.	c	d	b	d	c	e	e	d	d	e	a	a	c

RANK LISTS FOR THE EXPERIMENTS PERFORMED DURING THE THIRD YEAR

III. Rnj. Subject	Keats XV	Byron XV	Gray XV	Coleridge XV	Browning XV	Tennyson XV	Shakespeare XVI	Arnold XV	Shakespeare XVIII	Shakespeare XV	Wordsworth XV	Shakespeare XVII	Shelley XV
B.	c	c	d	d	b	a	e	b	d	a	b	c	c
F.	b	b	c	a	a	e	b	c	b	b	a	a	b
K.	e	d	b	e	d	c	a	d	e	d	e	e	e
L.	a	a	a	c	c	b	c	a	a	c	c	b	a
M.	d	e	e	b	e	d	d	e	c	e	d	d	d

	Cowper XV	Swinburne XV	Rossetti XV	Rossetti XVI	Dryden XV	Dryden XVI	Swinburne XVI	Spenser XV	Sydney XV	Jonson XV	Pope XV	Shakespeare XIII	Shakespeare XIV
B.	d	c	c	a	d	a	e	c	c	d	e	c	c
F.	b	a	a	b	a	c	d	b	d	a	a	b	b
K.	e	d	e	c	b	d	a	d	e	c	d	e	e
L.	a	b	b	e	c	b	c	a	b	b	c	a	a
M.	c	e	d	d	e	e	b	e	a	e	b	d	d

The rank lists for these experiments show much steadiness, but inasmuch as there were but five subjects, the possible deviation from position is very slight. Correlation between the feeling tone and the motor discharge remains the same as it was in the second year's work; to the very end, the mean variation and the range do not seem to have anything to do with the matter, or at least, very little in comparison with the mean of the tappings.

Let us turn to the graphs for these 26 experiments. In nearly every case the "short" vowels, whether accented or unaccented, and the explosive consonants produce a greater motor discharge than the softer, "slower" and more mellifluous sounds of the language. We give the figures for verification.

Experiment	Accented short vowels	Unaccented short vowels	Accented explosive consonants	Unaccented explosive consonants
Keats XV............	25	39	43	15
Byron XV...........	24	33	15	24
Arnold XV...........	19	39	27	18
Tennyson XV........	12	35	36	24
Shakespeare XVI.....	10	16	15	11
Shakespeare XVII....	8	18	17	5
Shakespeare XVIII...	10	19	18	8
Cowper XV..........	27	40	33	23
Shelley XV...........	18	42	34	18
Wordsworth XV.....	18	30	18	20
Gray XV.............	14	39	32	20
Sydney XV...........	14	28	38	21
Jonson XV	21	31	28	28
Pope XV.............	23	40	29	18

Experiment	Accented short vowels	Unaccented short vowels	Accented explosive consonants	Unaccented explosive consonants
Spenser XV..........	18	41	43	19
Browning XV........	24	32	31	20
Dryden XV..........	25	33	40	19
Swinburne XV.......	19	31	31	15
Dryden XVI.........	10	38	38	17
Swinburne XVI......	15	27	24	18
Rossetti XVI.........	26	27	37	13
Shakespeare XV......	19	28	24	21
Rossetti XV..........	19	33	27	17

By referring to the graphing for the two experiments on Shakespeare, XIII and XIV, it is found again in this case, as we have noticed before, that the transmogrification of a passage of poetry tends to arouse the motor consciousness more than does the original poem.

From the above results, it seems clear that the short vowels and the explosive consonants, regardless of accented or unaccented position in the poetic foot tend to produce the strong motor arousals; but this was not the case with the earlier experiments in which the single line was repeated five times in succession; nevertheless, the summation of effects is evidently what accounts for it, together with other factors not to be overlooked. The motor setting preparatory to tapping a long passage of verse is different from the motor setting which merely repeats the same line over and over again; and with the appearance of new combinations a stronger effect is produced by the addition of like elements than by a great variety of elements giving no effect of homogeneity; once the feeling produced by the short vowels and explosive consonants is aroused, even the lessening of their number per line in the following lines might not show as soon in the motor consciousness as it did in the introspective consciousness; instances of this we have seen in the previous pages. But it does not seem to work the other way around,—the effect of explosive sounds is immediate upon the motor consciousness, and one such sound can mar the effect of an otherwise placid and liquid line, and this may account for the apparent partial lack of definite

one to one correspondence which we have sought for in connection with our study of the motor energies and the introspective consciousness both singly and together.

Allied to the characteristic form-quality in the graphs for each individual poet, especially in the more meaningful lines experimented upon, is the matter of the tapped strokes as they appeared upon the smoked paper ribbon. After they had become accustomed to the tapping, every one of the subjects tapped in what could be called a thoroughly individual manner. Some of them tapped slowly and with great deliberation, thereby making a visible record of very rounded loops; others would react by a very quick down-stroke, followed by a slow, hesitating up-stroke, while still others would tap strokes that appeared on the paper as very fine points, or even in some cases would move the finger so quickly that the pointer climbed the roller on the up-stroke and returned with sudden relaxation of the rubber band in such a way as to make a loop in the smoky surface of the ribbon. And here lies the interesting point: that in the variously individual records there appeared evidence of all felt and unfelt changes in the emotional character of the experiments presented; tenseness of the vocal apparatus as well as the opposite state could be told by the experimenter as well as by the subject, together with subliminal effects of one sort or another which the subject did not feel either in summation or otherwise. Illusions, also, of various character were there evidenced, such as temporal and numerical ones. In general, the qualitative and quantitative aspects of the visible record amply supplemented the introspection in every way.

We have made no special mention of the time element in connection with most of these experiments. This is because the graphs are so typical for each and all of the subjects, that individual mention is unnecessary; furthermore, the time element does not seem to play any very important rôle. It certainly is no special correlate of any of the affective elements in consciousness; and it does not seem to be a manifest index either of difficulty in the material to be recited or of the number of sounds in the decasyllabic line. The subjects were all told to take their own

time in the tapping; this was merely to assure them that they were not to be hurried in what they did. This, however, is to be noted as the regular temporal manifestation of all the subjects: the repetition of the same iambic line five times usually showed on the record as having taken longer time with each repetition,—that is, the oftener repeated, the slower it became, though none of the subjects were aware of it. This may have been due to a num- of things: either slight muscular fatigue, or else to the fact that as the impression aroused the introspective and the esthetic consciousnesses more and more, less and less nervous energy was sent per impulse per unit of time into the finger. That it was not due to imperfections in the machinery is clearly shown by the fact that the ribbon was allowed to pass several inches before the pointer was dropped upon it and the signal to begin was given.

A very pertinent question to be asked about all this work is,—"What had the subject's general condition, mental and otherwise, to do with the results of the experiment?" A careful record was kept all during the second and third year as to how the subject felt at the beginning of the experiment and the results showed that the main effects of fatigue and other sub-normal states were of several kinds: 1. A less high degree of pleasurability can be aroused in the state of fatigue; 2. The mean variation of the tappings on fatigue days is less than on normal days, but 3, that the subject did not reverse the results of the previous experiments at all,—those who showed a positive correlation showed it still, and those who before had showed either a definite negative correlation, or a scatter and miss correlation also continued to do so; the more the experiment develops, the more it seems that we were getting motor correlations with respect to the vocal apparatus, rather than results which attached significance to the total psycho-neural mechanism. But to return to the matter of fatigue days, only one of the subjects, L., tended ever to nullify his previous results, but then he also attempted to guess at his own type of correlation, and this guess may have influenced the tappings for that day.

Not every anticipation or conjecture with which this work

began has been verified by the experiments so far presented. But that the first statement of the thesis was not so dismally at fault is at once evidenced by the introspection on these large transmogrifications of English poetry; the tonal elements of the poetic line do seem indeed to have the power of arousing a mood congruous to that of the original poem, even when torn from their positions and their rhetorical anchorage, and recast into such form as is shown in the above experiments. The subjects did not know at the time what poems were being given them in this potpourric manner; they only knew it was some poem, and that they were to introspect upon it; but it was not a guessing contest in any sense of the term,—all intimations that it was to be such were stifled at once; and to the subjects must be given due credit for their admirable interest in the experiment from start to finish, for in such fragile matters as the moods of the esthetic consciousness, any hostility or any lack of true scientific interest would have been fatal to the purpose in hand.

4. THE PSYCHO-PHYSIOLOGICAL VALUE OF THE POETIC SUM

The question of a tonal calculus seems to be the logical development of the foregoing experimentation. It has been shown that short vowels and explosive consonants are provocative of more motor arousal than the long vowels and the liquids. Strictly speaking, as has been indicated before, the term "long vowel" is equivocal. Except, of course in vocal music, where the long notes rightly function their enunciation. But if the question be asked: can we say that this or that number of sounds will produce this or that effect? the answer cannot be given in the affirmative without the following reservations: effects can be calculated, provided the number and arrangement of the sounds be taken into consideration. In the above experiments it appeared that if a number of explosive sounds began the line or the passage, then the motor manifestations were intense, and also that such manifestations did not wear away as soon as the type of sound had changed to some less intense one. Changes in the apperceptive

consciousness did not either run parallel with the motor pattern nor did they very often seem to be influenced by the finger as much as by the page of print. Yet the introspective and motor results were parallel in other ways, as has been mentioned so frequently before.

Only so far as we had data from simple vowel and consonant experiments, could a tonal calculus be made. And so, when even in the simplest of the I-XII experiments, there were found sounds upon which no previous experimentation had been done, their values were not known in the same way as the values of the simple sounds previously used, and no two lines of the I-XII experiments could be found which had the same common parts known and unknown, in respect to psychomotor value.

Much thought and time was given to this matter, and for a while it looked as if we had arrived at a solution of the problem involved. But it had to be given up, and for this reason: that while in nearly all the cases tried, the psychomotor values of the separate letter sounds as found in the ninety-six preliminary experiments upon the single vowels and consonants showed in summation to be equivalent to the psychomotor values of the first three experiments performed upon each of the poets, and that as more and more meaning came into the experiments the sum was affected by some other element,—yet inasmuch as we did not have enough tonal elements to make a full correlation, and inasmuch also as the later poets experimented upon did not give favorable results, presentation of data and pressing of proof is withheld at this time. We had but four long vowels and no short ones, and it is likely also that the average motor effect of the consonants we obtained would have been greatly modified by further experimentation with other vowels, both long and short. Hence this problem of poetic sums remains for the time being unsolved; were this experimentation to be repeated, that problem would stand uppermost in the attempts at correlation.

Only in the longer passages does there seem to be a trend toward a tonal calculus. And here, the surprising thing is that a very small number of explosive sounds in one passage over

those in another produced a motor difference greater than that deducible from the single effects of the elements involved. A very rich experimental field lies right here, and, with the method and results of this experiment herewith presented, ripe and free for exploitation.

Futhermore, with the tabulations of sound frequency before him, one could build up by the method of experiments I-III such experiments which would signify and also contain the tonal body of any of the poets contained in it, and then, by comparing the results thus obtained with those from large "ex poematis" passages see whether parallel effects were thus obtained. The tonal pattern of poetry is quite more definite than hitherto suspected, and a poet may be known by his overtones as well as by his subject-matter and stanza form.

Little need be said in conclusion other than what we have given as results in preceding pages. Upholders of the tonal theory of poetry may take a fastidious pride in some of the findings of this experimentation, and recollect that Edmund Burke's theory of poetry may again be referred to without apology. Certainly it is not the intention of this paper to neglect the formal element of the matter, even if the constancy of a rhythm form was used for the purpose of neglecting the form in the final account. It is not an impossible assumption that poetry as well as other forms of art may possess in each of their leading features, form and content, a sufficiency of emotional wealth to be considered each alone as able to arouse the esthetic consciousness to the full. The union of the two may add nothing but unity,—and hence all such experimentation as the above is perhaps more of a training in the direction of attention than it is a splitting of the elements of art asunder. Nevertheless, this must be left for the consideration of those who are better qualified to decide it than the writer.

Our study is completed for the present. So far as we know, no such work has ever been attempted previously; let us hope that future experimentation along the same line will profit by our mis-

takes and lead our results to something finer and more conclusive. Eight years of work culminate in the results we have brought forward, in which years eighteen thousand lines of poetry were phonetically measured and tabulated, involving the enumeration of nearly 540,000 sounds; the measurement of the records obtained in the laboratory involved nearly 300,000 bits of data; the computation of the mean, the mean variation and the range for all the experiments and the making of rank lists brings the total number of computations to more than a million, and with all this labor, it might seem to some that far more should have been found out concerning the psychophysics of poetry than we have to offer in closing. But the introspective consciousness and the motor, too, are not such things as can be coerced and cajoled,—all their laws are by no means sun clear, and to have found out something definite is better than to have been given only shadowy hints, promises, and false signs to advance.

There were in all fifteen persons who took part in this investigation. One of these was an instructor in the Department of Psychology. The rest were mostly graduate students in the Laboratory. Five were women from Radcliffe College. All were trained introspectors.

The following scheme shows what subjects took part in the investigation and for how long time:

Yr. I	A	B	C		F		L		N			T	W	Z	Y
Yr. II	A	B	C	D	F	K	L	M		P	S				
Yr. III		B			F	K	L	M							

Thus three continued through the whole period, and the some five subjects assisted during the last two years, in which by far the most important work was done.

The following account briefly indicates the chief characteristics of the subjects:

A. Predominantly visual; disliked the tragic and melancholy; closed his eyes whenever possible; nodded head synchronously with the tapping; often read in a slightly mournful tone; it was usually unpleasant for his own personality to be injected into the imagery; good sense of rhythm; very constant and steady.

B. Visual-motor type; enjoyed the tragic and melancholy as much as the light romantic; acquainted with English poetry, favored Byron, Keats and Arnold; he alone of all the subjects gave much introspection of the sensations of the speech apparatus; gave much introspection; good sense of rhythm; steady and constant.

C. Motor type; rarely got satisfying imagery of any sort; had great difficulty to count the five iambics in the "la-mo" type of experiment; sense of rhythm varied much with the type of experiment; introspection meagre; steady and constant.

D. Very visual, with highly colored images; artistically gifted and fond of poetry; enjoyed the bizarre as well as the sombre; rather volatile, but rebounded instantly from depressed states; strong sense of rhythm.

F. Visual-motor; fond of poetry; good declaimer, and often varied from a steady recitation of the material experimented upon; articulation sensations often seemed to determine the imagery; German: had some slight difficulty in pronouncing the "th" and other sounds; strong sense of rhythm; constant.

K. Visual-auditory-motor; musical performer; esthetic; liked the melancholy; voice usually of medium pitch but very low intensity; pitch constantly noticed; feeling of hoarseness accompanied low pitches; tapped very short strokes, often no more than 12 mm. in length; syncoped the tappings very frequently; good sense of rhythm; constant.

L. Visual-motor; artistic, and fond of certain kinds of poetry, *e.g.* the sound of Shelley's and the content of Arnold's; introspection varied much, from bare feeling-tone to full auditory-visual-motor content; very apt in describing vague content by fitting analogy; good sense of rhythm; steady and constant.

M. Motor type; practical, and impatient of most poetry; often given to intentional changes of extent of finger movement; wanted objective finger control (the most inconsistent subject as far as any feeling-tone =motor-discharge correlation was concerned); said: "I have a good sense of rhythm," which did not always appear.

N. Motor-visual; philistinian toward most poetry; frequently interrupted the experiment with a Phillipic on the impracticability of art; good introspector; good sense of rhythm; fairly steady and constant.

P. Motor type; musical; singer; enjoyed the less romantic forms of poetry; meagre imagery; left-handed (the apparatus was accommodated to him); tapped the longest strokes of any one (140 mm.) with the smallest M.V.; good sense of rhythm; steady and constant.

S. Visual-motor; enjoyed poetry of all kinds; introspection often by tactual analogies; had difficulty with the language, being a native of India; good sense of rhythm; fairly steady and constant.

T. Predominantly visual; fond of all kinds of artistic work; introspection clear, often chromatic; sense of rhythm well marked; steady and constant.

W. Visual; practical and little acquainted with or appreciative of poetry; counting the five iambics often very difficult; tapping never become pleasantly automatic; steady and constant.

Z. Visual-motor; enjoyed poetry and was somewhat gifted in verse-making; lack of imagery in the introspection often disappointing enough to change the whole feeling-tone; steady and constant.

Y. Visual; acquainted with English poetry; introspection rather meagre; strong likes and dislikes; good sense of rhythm; steady and constant.

My thanks are due to both Professor Hugo Münsterberg, director of the Harvard Psychological Laboratory, and to Dr. Herbert Sydney Langfeld, Instructor in Psychology, for their kind and continual interest in and criticism of this work. And to the subjects who took part in the investigation much praise is rightly bestowed for their perserverance and interest.

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Standardization of Tests for Defective Children

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VI

I

INTRODUCTION

The following study was undertaken to provide data for the standardization of the Healy-Fernald tests, described by the authors in *Psychological Monographs,* Vol. XIII, No. 2. It is offered because a standarization of these tests has been asked for by various persons interested in the development of clinical psychology. It is hoped that the study will also suggest some further clinical uses of the Binet-Simon series. The purpose of standardization is to show the reactions of a socially homogeneous group of individuals considered socially and pedogogically normal, classified according to certain principles discussed below.

The psychological considerations which underlie the author's classified evaluation of these tests has been found of value in clinics where the mentally defective must be distinguished from the mentally normal, and classified for the purposes of instruction in the public school and for placing in public institutions. It is hoped that the formulation of the principles which have led to such classifications may prove to be suggestive to those seeking further light on the process of mental diagnosis.

The study is offered, however, with a due appreciation of its incompleteness. It is desirable that a hundred or more children of each age and grade of the school should be given the tests discussed in the following pages, rather than the twenty which it was possible to get. But, though the numbers are small, they are sufficient to show clearly marked tendencies to specific types of reaction for the various grades and ages tested.

This work was done by the author while psychologist to the Juvenile Psychopathic Institute. This organization maintains a clinic at the Juvenile Court of Chicago. Wherever in this work "the clinic" is mentioned it is this clinic to which reference is made.

Much that is said in this study concerning mental tests in gen-

eral and concerning many of the individual tests is the result of a body of experience gained in the clinic just mentioned and a further year's experience in the clinic of the Department of Child Study of the Board of Education of Chicago. Much of this experience is not amenable to statistical classification. The particular bit of work which is here used for standardization of the Healy-Fernald tests is especially suitable for this purpose because it is gained from a group of socially homogeneous subjects.

The work of the Juvenile Court clinic is entirely with the juvenile delinquent; and except for this one characteristic that group of cases is not homogeneous. The work in the Department of Child Study is with children who for some reason are reacting unsatisfactorily to the school situation. This group of subjects is far from homogeneous mentally, physically and socially.

Since one of the reasons for atypical social response may be mental defectiveness, the reaction of what has come to be accepted by the users of these tests as mentally defective response has been compared with the mentally normal for each test. The factors which enter into consideration in classifying as mentally defective are discussed on page 164.

Subjects.—The children who served as subjects for the tests comprised the kindergarten and first six grades of a private school in Chicago. These children composed as perfectly homogeneous a group as it is probably possible to find in a school. They were the children of people of the professional class mainly. A few were children of successful business men who sought the best obtainable type of education for their children. The school was founded for the purpose of putting into application the broadest and best conceptions of educational theory and practice.

So far as heredity in its relation to social class is concerned these children were equally endowed. Home environment with reference to educational endowment and stimulus was uniform as nearly as such a matter may be measured. One may assume that the children who belonged to the same grade had had the some educational régime in home and school.

II

HISTORICAL DEVELOPMENT OF TESTS OF MENTAL MEASUREMENT IN CORRELATION WITH GENERAL INTELLIGENCE

Psychologists have for some twenty years been concerned with finding a measure of general intelligence. Work with different types of tests under more or less rigorously controlled laboratory conditions has been carried on with children of different classes and with college students, graded in one way or another according to degrees of general intelligence. Within the last ten years there has arisen the need of application of the work of the laboratory psychologist to the practical work of clinics for investigation of socially atypical individuals. In the United States and other countries the criminal, the mentally defective, the backward school child and the supernormal child are being investigated with greater thoroughness than ever before. To meet this need there have been devised and invented tests for measuring mental ability of a type quite different from the tests devised by the early laboratory psychologists who worked at the problem. A short historical survey will serve to characterize the two groups of practical tests discussed in this article.

Only a part of the great mass of literature on tests of general intelligence is outlined in the following summary, namely, that part which endeavors to establish a measure for the general intelligence of children.

In 1897 the American Psychological Association (1) received the report of a committee appointed at its previous meeting to investigate the subject of physical and mental tests. This committee agreed upon and reported a series of tests which it recommended be tried on college students in the various psychological laboratories of the country. The physical and mental tests recommended were classified as follows:

Preliminary Data.—Date of birth; birthplace; birthplace of father, birthplace of mother; occupation, including class in college; occupation of father; any measure previously made. Color of eyes; color of hair; right or left handed. Mother's maiden name; number of brothers; sisters; order of birth; age of parents at birth; birthplace and occupation of grandparents. Assymetry of body; color of eyes, hair, complexion; degeneracy or other stigma of head, eyes, ears, mouth, teeth, hands, feet, posture; gait; manners; coördination and speech; indications of intellectual, emotional and moral characteristics.

Physical Measurements.—Height, weight, and size of head. Breathing capacity. Height sitting.

Keenness of vision
Color vision
Keenness of hearing
Perception of pitch
Fineness of touch
Sensitiveness to pain
Perception of weight or force of movement
Dynamometer pressure of right and left hand
Rate of movement
Fatigue
Will power
Voluntary attention
Right and left hand movement

Rapidity of movement.—Taps on telegraph, short marks, trilling with two fingers or five.

Accuracy of aim
Reaction time for sound
Reaction time with choice.—Card sorting

Rate and discrimination of movement.—Marking out 100 a's in 500 letters, one of a number of geometrical figures, or colors, or pictures, or objects.

Quickness of distinction and movement.—Rate at which cards are sorted, combine with reaction, with choice, with effects of practice.

Perception of size.—Draw a line equal to a model 5 cm. in length, bisect it, erect a perpendicular of the same length, and bisect the right hand angle.

Perception of time.—The accuracy with which a standard time can be reproduced.

Memory.—The accuracy with which eight numerals heard once can be reproduced, and the accuracy with which a line drawn by

the observer at the beginning of the hour can be reproduced at the end of the hour; line to be identified, not drawn; ten numerals; nine numerals. A combined test of memory, association and finding time as described in the catalogue of the Columbian Exposition, accuracy of observation and recollection as proposed by Cattell and Bolton.

Memory type.—Variation in the use of ten numerals, compare results for indication of memory type and kind of imagery preferred.

Apperception test of Ebbinghaus

Imagery

Much, and more than was here recommended, of this work was done in the next few years, and the attempt was made to correlate the results with other evidences of general intelligence.

Before this time, however, some very important pieces of work had been done. One of these was the work of Gilbert (2) in 1894. Gilbert correlated weight, height, lung capacity, simple reaction time, reaction time with discrimination and choice, and time memory with mental ability. In determining general mental ability the teacher's judgment was relied upon. Each teacher classified her pupils as bright, average and dull. Approximately 100 children of each age group from six to seventeen were measured.

Porter (3), in 1893, correlated the height and weight of 33,500 school children with age and grade.

Later Smedley (4), in 1900, correlated height, standing and sitting; weight; ergograph and dynamometer records, and lung capacity with age and school standing of children between the ages of eight and eighteen inclusive.

West (5) correlated physical development and intellectual ability of Toronto school children. His method of grouping for intellectual ability was according to the teacher's estimate of the children as good, average, and poor.

The investigations of the men mentioned and others gave rise to three different conclusions with regard to the relation of physical development and mental ability. Porter, Smedley and some others found a positive correlation between physical development and mental ability of which success in school life was taken

as the measure. Gilbert found no correlation and West found a negative correlation. These differences were probably due to different arrangement of data and to different methods of grouping grades of intellectual ability. Gilbert did not separate the sexes in his tables and did not state the proportions of his dull and bright groups. Gilbert and West classified according to the teacher's judgment; Porter and Smedley according to school grade with reference to age. A severe criticism of the method of classification according to teacher's judgment may be quoted from West's account of his experience with it:

"It soon became apparent to me that any such classification of children's mental ability would be very greatly influenced by the mental caliber of the teacher making the classification. . . . There were no poor scholars. The teachers were perfectly willing to classify the scholars as of good and average intelligence but any intimation of poor or stupid scholars was taken as a personal reflection upon the teacher of the class in question. . . . The poor students were no more than a mere handful."

The method of grouping according to success in school life, the method of Porter and Smedley, grades all children of the same age according to the same standard. Though some allowance must be made for a small group compelled by individual circumstances to residence in grades below that of which the mental ability of each individual might otherwise permit.

In the reaction time tests Gilbert thought to have found a correlation with intelligence. He says, "The curves for reaction time gave the most positive results showing that the brighter the child the more quickly he is able to act. In discrimination the same relation is true but to a less degree. . . . Of time memory it may be said in general that the brighter the child the more accurate his sense of time." An examination of Gilbert's tables, however, fails to support so optimistic a view of the existing correlation. At some ages the dull class is superior to the bright class, and the differences between the three classes measured are everywhere slight.

Reaction time tests of various kinds were tried out by various investigators in the following years. The results of this work

were reviewed by Whipple (6) in 1904. He distinguished between two kinds of reaction time experiment, the laboratory type, and the anthropometric type which includes card sorting and similar tests. The former consists of work done under rigid laboratory conditions upon subjects competent to make introspective analyses. The latter consists of experiments made on children or others without introspective analyses and without practice in direaction of attention. He pointed out that because different experimenters obtained widely varying results under the same conditions, attention came to be directed to the different types of individuals, and the reaction time experiment came to be an experiment in reaction consciousness. The anthropometric type of experiment he criticised, because the conditions under which the data were supplied, were so loosely controlled that one could not be sure what was measured. He concludes that any reaction time is conditioned upon a large number of independent factors and when these are eliminated or controlled in the laboratory "we have left no residuum of individual variation that can be turned to account in estimating the observer's general intelligence or mental ability."

In 1901 Wissler (7) published the results of a long series of tests and anthropometrical measurements made under the direction of Cattell upon students of Columbia University for a period of seven years. The results of these tests were correlated with class standing. The general conclusions were that the laboratory mental tests show little correlation in the case of college students; that the physical tests show a general tendency to correlate with themselves but only to a very slight degree with mental tests; that the markings of students in college classes correlate with themselves to a considerable degree but not with the tests made in the laboratory.

Griffing (8), 1895, and others investigated the subject of attention with reference to general intelligence. In general some form of the tachistoscope was used. Griffing's conclusions represent the general concensus of opinion among these investigators. He said, "I found that those rated 'A' for mental capacity by the teachers on an A B C basis, had somewhat higher averages than

the others. . . . There are, however, marked exceptions. . . . Those marked 'A' by their teachers for attention in class also excelled the others, but here also I found decided exceptions. Many pupils must have, therefore, good powers of attention, even when they show no evidence of them to their teachers."

In 1904 Spearman (9) made a critical analysis of the methods of work in the determination of correlations of various tests with general intelligence. With a more exact mathematical formula for the calculation of correlations and by the use of more factors for the determination of general intelligence he found large correlations in tests of discrimination of grays, and weight and pitch, with general intelligence.

In 1909 Burt (10) correlated the general intelligence of two sets of English schoolboys with tests of discrimination of two points upon the skin, of lifted weights, of pitch, and of length of lines. To these he added two motor tests, tapping and card dealing; two sensori-motor tests, card sorting and alphabet finding; tests of immediate memory of concrete words, abstract words and nonsense syllables; the tracing of a geometrical pattern seen in a mirror, a test of the power to acquire new coordinations; the reproduction from memory of a pattern of spots presented by the tachistoscope upon squared paper; and a test of voluntary attention, which consisted of pricking an irregular line of dots passing rapidly before the subject.

Great care was exercised by Burt, in accordance with the recommendations of Spearman, in the mathematical work of correlating the test findings with general intelligence. The latter was estimated by the headmasters of the schools from which the reagents came. The conclusions at which Burt arrived are as follows:

Of the simple sensory tests, tactile, weight, pitch, and length of line discrimination, he says, "There appears to be no general connection between intelligence and capacity to discriminate weights; any connections between intelligence and tactile discrimination, if it exists, is of the slightest; there is considerable connection between intelligence and capacity to discriminate undoubted general connection between intelligence and visual discrimination of lengths. . . . "

Of the motor tests, tapping and card dealing he says: "Motor tests seem to have a higher correlation with intelligence than sensory tests. But where rapidity is due to frequent practice. . . the correlations with intelligence and other tests are reduced, abolished, or inverted. Thus so far as motor rapidity is the function of temporary 'facilitation' of the paths of neural discharge it appears also to be a function of intelligence, while so far as it is a function of permanent 'canalisation' of those paths it is but slightly or inversely related to intelligence." This latter conclusion was the result of disturbance of correlational results among a group of practiced card players.

Of the two sensori-motor tests, one for the sorting of cards according to color, the other for selecting a complete alphabet from a mixture of two alphabets, Burt says: "Depending as they do for their performance upon processes of a more complex nature and a higher mental level, tests combining perception with motor reaction seem to involve the intelligence to a still higher degree than relatively simple sensory or motor tests. Of the two above discussed the alphabet seems to be, in practice, far the more efficient."

Immediate memory was tested by the use of sets of words of abstract significance, of concrete significance, and nonsense syllables. The correlation with general intelligence found by Burt between concrete memory, abstract memory, and nonsense memory was .58, .48, .43 respectively for one group of boys and .84, .78, .75 for another group. "Thus the memory for abstract words does not show a higher, but a lower correlation, with intelligence. . . . The introduction of difficult vocables, whether abstract nouns or meaningless syllables, proves in both groups to be on the whole a distracting element."

In the mirror test, a pattern is traced which, with the hand doing the work, is seen only in a mirror. This tests the subject's ability to readjust certain already learned eye and hand coördinations to a changed situation. Burt found many difficulties in the mechanical operation of this test as well as in the method of measuring results. In his judgment it was a test which with further perfection would be of great practical value. He, how-

ever, sums up the factors which would complicate and make uncertain the results of this test in practice when he accounts for the divergence between his two groups of the correlational figures, .67 and .54. "The divergence between the two schools is largely due to the fact that four of the Preparatory schoolboys had had previous practice at an analogous task in the form of a not very common parlor pastime. Only one of the thirty Elementary boys had done any similar exercise before. The divergence might also be in part attributed to a greater familiarity with the use of the mirror among boys of a higher class as compared with boys of a lower status. A similar factor apparently operated when the test was applied to children of the opposite sex, though subsequent application to very young children, and to adults, have led me to wonder whether we are not dealing with one of the uninvestigated innate differences between the sexes."

The spot pattern test was given in a dark room by means of a tachistoscope. The pattern was shown as many times as it was necessary for the subject to learn to reproduce it correctly. The difficulties in the use of the tachistoscope in practical work are indicated when he says, "The tachistoscope was found to require a larger amount of experience on the part of both subjects and operators, than any of the other tests, except perhaps those involving sensory discrimination. . . . The first series of all had to be rejected as worthless, owing partly to the irrelevant excitement aroused in the subjects by the 'electrical flash' as the boys named it. . . . At this school we were not able to obtain the complete darkness and silence procured at the other in our extemporised dark room, and consequently the reliability coefficient and the raw correlations with intelligence are not so high." The coefficient obtained was .76 and .75 for the two groups.

Burt's test of sustained attention consisted of pricking dots irregularly arranged upon a strip of paper which passed before the subject. The number of dots per minute which the student marked constituted a measure of his ability. The correlation for this test with general intelligence was found to be .75 and .96 for the two groups of boys.

Of the practical significance of these tests Burt says: "Of the twelve tests six furnish coefficients below .50 and six above .50. The former six—the simple sensory and motor tests—are thus of little use in the empirical diagnosis of intelligence. Among the latter six, no single test, at any rate in its present form, can be claimed as a self-sufficient instrument for measuring and detecting ability in individuals. But they indicate the direction in which such a test may hopefully be sought. . . . McDougall's dotting machine seems to be the most scientific. Where the external conditions could be kept most uniform, . . . both the amalgamated and the average raw coefficients reached .84. Such uniformity is difficult in more extensive work, and the ensuing variety in attention and fatigue affect the performances with this test. Moreover, its figures are less discriminative than either of the other three. By increasing the number of spots in the pattern the tachistoscope test may be made to differentiate with almost any degree of minuteness. . . . It is a slow test, however, and without repetition scarcely reliable. And it calls for some experience both on the part of the boys to grasp the nature of the task, and on the part of the experimenter to manipulate the apparatus with regularity. . . . The mirror test can be procured with but little trouble and expense, and needs no trained superintendent. It, too, requires further improvements, especially in procedure and calculations, to eliminate the influence of possible previous practice, and to elicit more completely the significance of the figures observed. If called upon to recommend a simple test for immediate use upon untrained subjects, I should be inclined to advocate the alphabet test as perhaps the simplest and most satisfactory test of all."

The work of Burt has been so fully recorded because it is the broadest and most careful attempt to correlate the results of tests with general intelligence. In this work many considerations were taken into account in constructing a scale of general intelligence of the subjects. Great care was taken in the management of the tests themselves and the mathematical correlations were worked out with accuracy. The conclusions drawn of the vari-

ous tests are valuable from the standpoint of an interpretation of intelligence. For various reasons, however, the results can not be immediately applied to clinical work. The reasons may be grouped under five heads.

The first and most important is the measurement of the tests against time. It is the experience of the writer and others in the work of children's clinics that time within the limits of rigid laboratory procedure can not be taken as the measure of the subject's ability with a particular test. This is because of the peculiar demands of such a clinic. One wishes the child to be unaffected by any feelings of fear or anxiety or strangeness with the situation when he comes up for examination. As far as possible he should not know that he is being examined. He, therefore, should not be subjected to the anxious desire to make good time in any thing he is doing. There are few tests which can at all lend themselves to such measurement, since in any test which can be useful as a measure of intelligence or which can show the child's intelligence functioning, there are involved perceptual or other types of discrimination which may be interfered with if the child anxiously desires to make a good time record. This interference with thought processes may cause the final result to be a misleading and perhaps unfair judgment of his general intelligence. Only such discriminations as are habitual with him and therefore make little demand upon attention can be measured against time. Under such circumstances one does not know what is being measured.

The second reason for the impracticability of Burt's work is the fact that with tests which correlate most highly with general intelligence, the use of apparatus is necessary. Burt, himself, showed how the tachistoscope mechanism interfered with attention to the object of the test itself. In much larger measure would such a piece of apparatus be a stumbling block in a clinic where defective individuals are examined. As was remarked above, one wishes the child to be unaffected by any feelings of fear or strangeness with the new and usually strange situation into which he is thrust when he comes to a psychological clinic for examination. A piece of strange apparatus will so

fill his mind with fear or speculation as to its object and its affect upon himself, that he may not act normally. The fact also that much practice is needed on the part of the subject to use a piece of apparatus must put it out of consideration for the practical clinician.

The third reason for discarding some of these tests is that previous practice may vitiate results. What Burt has said with regard to the mirror test and card dealing test has already been quoted. No tests except those on reading, arithmetic or other subjects of cultural value can be used in a practical clinic which in any way may have been the subject of practice on the part of the child, and these only if the examiner knows the extent of the child's experience with them.

The fourth point of error in applying the work of Burt, and all other works of its type, to the examination of atypical children is that it does not take into account the child's motive for action. In child life there are in general two motives for voluntary activity. One of these is the play motive, in which the child voluntarily seeks the end to be attained. The other is the social motive of pleasing associates, who may demand ends which he would not voluntarily seek to attain. In a psyschological laboratory the motives of the adult subject and the observer are the same,—the production of scientific data. In such case the subject lends himself willingly to any conditions imposed. Knowing the end of the experiment he is able to direct attention to the attainment of that end and away from the distracting elements of unusual conditions. It is otherwise with the child. With him the motive most conducive to natural reaction, uncomplicated by disturbing emotions, is the play motive.

The fifth reason for the lack of applicability of this type of work to a practical clinic is that it has been done with subjects of so high a type of mentality that the results are of little value in measuring low types. A mathematical statement of the correlations of a test to the general ability of such subjects as form the reagents for experiments under laboratory conditions can have little significance in a clinic for defective

or abnormal individuals. The subjects for laboratory experiments are in general of a high type of intelligence. Among Burt's subjects there was only one defective child. In a clinic no child typical of the average in the social situation in which he finds himself, ever comes up for examination. Necessarily in some realm of social, mental or physical functioning, the child to be examined is abnormal or he would not be brought for examination.

A part of Burt's work, however, can be of greater value for clinic purposes than his correlations led him to believe. Such simple sensori-motor tests as card sorting, or as Whipple designated them, the anthropometrical reaction tests, have been found by him and other laboratory experimenters to correlate little with general intelligence. The reason for this is that even with the least intelligent subjects these tests fall well within the limit of their intelligence, and, therefore, can not form a measure of the mental ability of those particular subjects. With many subjects of the practical clinic, however, such simple tests may be of great value. If it is found that the child can do nothing more complex than sort cards according to color or geometrical form, or whatever type of discrimination is employed, this, in part at least, establishes a measure of his mental ability. If it is found that he can not do even these tests then others of a simpler nature still must be used as a measure.

Viewed from the standpoint of such use, the simple "anthropometrical reaction" tests are of great value as measures of certain elements of general intelligence. For use in a practical clinic any test may serve as a measure, in whole or in part, if it really does mark off a range of intellectual activity. However, no test can be of such general use as Burt thought possible of the alphabet sorting test which he considered most valuable as a test of mental measurement. The highly intelligent child can accomplish tests of far greater complexity; the low grade child may be unable to make such fine discriminations. This test, therefore can not serve as a measure of these two grades of mental ability.

To sum up, the clinic must discard time for the most part as an important factor in the measurement of results. This point is discussed further below in connection with certain tests. Some other measure, preferably a qualitative one, must be substituted for this quantitative one. The clinic must discard rigorous laboratory conditions and adjust its tests to conditions more in conformity with those of everyday life. It must discard such apparatus as requires practice on the part of the subject, or as is not directly connected with the object of the test.

It was such considerations as the foregoing which led Binet and Simon in 1904 to compile the series of tests which have since been rearranged and modified into the series of 1911 (11). In 1904 it was required that the mentally defective children in the public schools of Paris be segregated after individual examination. Binet, who had contributed in large measure through his laboratory experiments to the psychology of mental tests and mental measurement, undertook to arrange a series of tests capable of practical application to young children. These tests eliminated to a large extent, the quantitative measurement of results and substituted a qualitative measure. The requirement of laboratory conditions was discarded in favor of a situation more in accord with the normal every day life of the child.

III

THE BINET-SIMON TESTS

This series of tests marks the real beginning of the application of psychological tests to the practical work of discriminating defectives from normal human beings. Binet revised his first scale in 1908. In this form it was used largely by many experimenters in Europe and America. Later, in 1911, taking account of the criticism arising from these experiences with his scale, Binet again made a revision. Several experimenters have added materially to our knowledge of the usefulness of this series of tests under the conditions of practical work. Bobertag (12) has made a thorough analysis of the psychological significance of each test and applied the series to a group of German children. Goddard (13) applied it to four hundred feeble-minded children of the Vineland School for the feeble-minded, and to two thousand public school children. Kuhlman (14) used the tests in the institution for the feeble-minded at Faribault, Minnesota. Terman and Childs (15) applied the tests to a large group of normal children in California and suggested certain revisions and additions to them.

In the following discussion it is hoped to show something of the psychological significance of the individual tests of this series and its value in clinical work. Only so much of the description of each test and its application is given as will indicate the nature of the test. In some cases a more elaborate statement will be given where the author suggests a wider use of certain tests than that recommended by Binet. The discussion begins with the tests for five years because the writer's clinical experience with children under five years of age has been small.

Children of Five Years

I. *Compare two weights.**—Four boxes in sets of two are used. They are the same in appearance and volume and weigh

respectively, three grams and twelve grams; six grams and fifteen grams. The first two are placed on the table before the child and he is asked to lift them both and hand to the experimenter the one which is the heavier. This tests the child's ability to compare two sensations and form a judgment concerning them. The test is concerned with the ability of the subject to make such comparison and not at all with the keenness of his discrimination of differences of weight. The subject must also exhibit ability to interpret and classify his sensations in language. In the tenth year when weights are arranged in serial order the later test deals more with sensory discrimination.

Bobertag points out the interesting significance of correspondence of this psychological procedure with the highest intellectual accomplishments in science and practical life. A quantity of sensations are presented to the individual under normal life conditions, and these are arranged in certain classifications of different kinds. In this way order is established in the mental life. To be able to isolate in consciousness one type of sensation from all others and to arrange its variations in a serial order from little to great is the first necessity of conscious intellectual life.

Defective children will hand to the experimenter the one which happens to be the most convenient to pick up, or will do nothing at all because of lack of comprehension of the problem.

II. *Copies a square.*—To pass this test the subject must command three abilities. First, the comprehension of the square as such, a perceptual discrimination. The same type of discrimination is tested with the Seguin form board and sorting cards. Second, the muscular control necessary to make lines of equal length or approximately so; and third, the ability to coöperate the two foregoing processes for the production of the final result. If the test is not passed it may mean that the child has not a comprehension of the distinguishing characteristics of the model before him, or it may mean that he has not

* The descriptions of tests follow the translation by Town.[11] The Binet quotations are from the same source.

the motor control which will enable him to draw a model which he recognizes, or he has not made the requisite mental coöperation. Binet directs that the child be required to copy the square with ink, not pencil. This direction would indicate that the test was intended to be one of motor control as well as one of intellectual comprehension, since the use of the pen adds a motor difficulty.

The writer has seen defective children who were able to distinguish a square from a circle, or some other form, as was shown in the card sorting test in which cards were sorted according to the geometrical forms upon them; but were unable to initiate the process of step three sufficiently well to draw a recognizable copy of the model. Their copy was a mere scribble.

There also come to the clinic children suffering from nervous derangements, who cannot control the hands sufficiently to draw a straight or approximately straight line, or draw one of the length desired, and who therefore also fail to make right angles; but who, it seems evident from other tests which they pass, and especially from the dissatisfaction which they show with the result of their efforts with this one possess the two other abilities necessary.

III. *Repeat a sentence of ten syllables.*—Binet says of this test, "After the comprehension of words, the next step in the development of language is not, as one might think, the verbal expression of thought and the naming of desired objects, but a repetition of words heard. It is easier, approximately, to echo a word than to use it independently, to pass from an idea to a word." In giving this test one says to the child, "I shall now say something to which you must listen carefully and then say it just exactly as I do." Binet permits no error whatever in the reproduction of the sentences. The series of sentences given by Binet are:

I am cold and hungry.

My name is Gaston. Oh! the naughty dog.

Let us go for a long walk. Give me the pretty little bonnet.

Bobertag uses the following list:

I am a good child.

I have a pretty dog.
I sit upon a chair.
My brother has gone away.
I will go to visit my father tomorrow.
I have bought myself a new suit..
We have not yet done our school work.
Now we will go together to take a walk.
I have said to my brother that he should visit me.
When we have done our work then we may play.

Bobertag grades these from 6 to 16 syllables. The English translation makes the number of syllables in some cases slightly different. In such sentences as Bobertag's the writer finds a certain advantage over those of Binet. With the Binet set one necessarily drops the voice and pauses at the end of the short sentences, which constitute the set of ten syllables or more, and the child, on the qui vive to reproduce immediately, begins to do so as soon as he hears the drop of the voice, or the pause, not realizing that the set is not yet finished. There is probably a difference in the memory process of the two types of sentences. Binet assumes that the child does not attend to the idea but only to the words and reproduces them. The Binet sets contain more than one idea. That the process of remembering the sentence which is used for the expression of one idea, such as those of Bobertag, is easier than that of remembering a sentence of the same number of syllables which expresses two or more ideas is indicated by the fact that Binet found the five-year old child generally able to remember no more than a sentence of ten syllables, but Bobertag found that sentences of sixteen syllables were not too difficult.

IV. *Counts four pennies.*—This test shows whether or not the child has learned this series of four terms and has related the terms of the series to four like objects. Children may learn the counting series without relating it to anything; that is, without ever counting anything. General observation shows this to be the case with young children. A child of four, who could count to five as a mere word series, was observed

by the writer to make for himself the discovery that he could relate this series to five objects; upon the first occasion his five toes. To count something, then, is a step in advance of merely counting. Defective young children in the schools relate the counting series imperfectly, or not at all, to the objects before them.

Some defective children will relate the counting series perfectly to a series of objects; that is, they count correctly a row of objects but have no appreciation of the number concept involved. If, for instance, after the child has counted a series of four objects, he is asked, "How many are there?" the answer may be, "ten." If a row of objects, say two or three is placed before him, and he is asked to tell how many are there he will again count correctly as a series and relate the series correctly to the objects before him and answer wildly, "seven" or "nine."

The normal child of this age is able not only to count correctly, but also to understand that his counting numbers. He does not make so erratic an answer as has been indicated of the defective child. Binet and his followers have made this test rather a vague one by insisting that the child be asked to count four pennies and by pointing out that it is necessary for him to count some such series of objects which are of interest to him. The writer finds that if the child can count at all he can and is willing to count anything. The writer generally uses a row of small circles upon a sheet of paper. The child always counts these as willingly as he would count pennies, or other objects.

V. *Game of patience with two pieces.*—For this test an oblong card is cut along the diagonal, making two triangular pieces. An uncut card is placed on the table at the same time as the pieces of the cut card and the child is told that a card like the one before him was cut in two and that he may arrange the pieces as before it was cut. This tests his ability to construct from a given bit of material a product to correspond to a given model. Failure to do this is significant of the child's lack of constructive ability to the extent that the complexity of this work permits it to be measured.

Binet says of this test, "After the operation is analyzed, it is found to consist of the following elements: 1. To keep in mind the end to be attained, that is to say, the figure to be formed; it is necessary to comprehend this end, it is necessary also to think about it, not to lose sight of it. 2. To try different combinations, under the influence of this directing idea, which often guides the efforts of the child though he be unconscious of the fact. 3. To judge the formed combination, compare it with the model, and decide whether it is the correct one."

In the writer's opinion the cut pieces should be laid with the two long sides of the original rectangle parallel with each other, as in figure a or figure b. This compels the child to move one piece about in such a way that his getting the pieces in the right position immediately would not be the result of accident. To place the pieces as in figure c would permit him with one movement to get them in the right position and since this is almost the only movement which it is possible for him to make with them the final result might be merely accidental.

Children of Six Years

I. *Distinguishes between morning and evening.*—The question is asked, "Is it morning or afternoon now?" This tests the child's comprehension of this simple measure of time. The writer always asks, in addition, after the child's answer, "How do you know it is." The answer to this question always indicates the event of the day which the child has set up as his means of measuring time. He will say, "Because I have just had my breakfast," or "my lunch," or some event of the school day, such as "We had our reading." Many children, who answer the question wrong, will, however, answer properly such questions as, "Do you have breakfast in the morning or in the afternoon?" "Do you have supper in the afternoon or in the morning?" "Do you go to school in the morning or in the afternoon?", and so on. This further precautionary questioning shows whether or not the child has set up any type of time measure, though he may have failed to take notice of the

particular event of the day at the time of his examination, which divides morning and afternoon for him.

Binet says of this test—"One expects, we, ourselves, expected more brilliant results. We would have judged that children could distinguish between morning and afternoon long before the age of six. It is a distinction which appears so easy. Think of the fact that six-year old children are the oldest in the 'maternelle' schools. Recall that the program of these schools provide for the teaching of history and geography; 'the principal irregularities of the earth's surface, brief biographies from natural history,' read the rules of the schools 'maternelle' of the department of the Seine. Is it not rather ridiculous to talk about natural history to children who cannot yet distinguish between morning and evening."

Bobertag found that of 55 six-year old children 45 per cent answered the question correctly; of 126 seven-year old children 69 per cent answered the question correctly.

II. *Defines in terms of use.*—The child is asked successively "What is a fork? What is a table? What is a chair? What is a horse? What is a mama?" This tests the child's ability to abstract and put in language form certain characteristic qualities of familiar objects.

Binet finds that up to nine years of age the majority of children define these objects in terms of use only; of a fork, "It is to eat with"; of a table, "To eat on and to put things on"; of a chair, "To sit on"; of a mama, "She takes care of the children." After nine years of age the definitions are in terms superior to use. Of a fork, "It is an object used for eating"; of a horse, "It is an animal"; of a mama, "She is the mother of a child," etc. Other definitions superior to use are those which describe, such as "A fork has four prongs and a handle, it is made of silver," etc. Very young children will answer with silence or, "A fork is a fork."

Bobertag points out that many children, who are intelligent and who are not loath to take the trouble to think, remain silent or say, "I do not know." Certainly these children know what a fork is as well as the others who make some kind of

answer, and neither are they less experienced in the use of language. They make the problem a very difficult one for themselves and are in a state of mind similar to that of the adult if one suddenly asks him, "What is a hole?"; or what he understands by the term *state* or *truth*. That this is the condition of the minds of some children is shown by the fact that they are able to show a greater intelligence concerning the distinguishing characteristics of the articles for which a definition is asked if in the beginning one guides their thought in some direction. Such guidance may take the form:—'A fork is to— ?", or "A fork is of— ?", or "A fork appears how— ?". Children in their endeavor to find a good answer will sometimes whisper quietly to themselves "It is a— " Then they give up the problem and venture, "I do not know."

The writer has found many normal children who must be guided into an answer because they do not see the reason for asking, what to them, seems so simple a question. They have just the attitude of the adult when the latter is suddenly asked, "What is a fork?" So many possibilities for answer crowd into the mind and, not knowing for what purpose the question was asked, they stare and answer nothing. In the school in which these tests were given, the children of the second and third grades had studied and read of the customs of foreign people. It was found expedient to guide the child in this way: "You know in Japan they do not have forks. If you were there someone might ask you—What is a fork? What would you tell him?"

Bobertag maintains further that one is not justified in subordinating the use definition to other types of definitions of the object. He asks, "Is it not much more important that one should know of the fork that it is to eat with than that it is of iron, or pointed, or has a steel handle and two sharp points?" The use of the fork for eating is, he says, doubtless its most important characteristic. The others stand only in the relation of further information concerning the thing defined. It is probable that the tendency to add further definition to that of use is due, he thinks, to certain methods of school instruction.

In the school the question, "What is a— ?" is generally banned. If a teacher wishes to learn, for instance whether the child knows what a revolver is, he requires of him when he answers not only, "It is a weapon, or a hand weapon," but he also asks him how a revolver looks, what one does with it, etc. It therefore follows that the child of six years, who has had little of such training in exact expression, will answer the question, "What is a fork?" with what had to him been the distinguishing characteristic of a fork, and the most important in his experience. The older child adds in addition to this or substitutes for it some such further information as Binet designates, "Definition superior to use."

That the definition may be made of further use for measuring mental development than that conceived by Binet is shown by Bobertag with the use of more and other words than those used by Binet. Bobertag uses the following words:—fork, chair, tongs, kitchen, doll, carriage, horse, soldier, penny, rose. These were selected because—1. They could be easily defined by use. 2. They could be easily defined by description. 3. They could be easily defined by means of classifying concepts. The development of the child from the use concept to the class concept in his definition of words is shown in the following table.

Age of Child	*Fork*	*Chair*	*Doll*	*Horse*	*Soldier*	*Credit given by Bobertag*
5 yr.	Knife	———	Frieda has a doll	It has ears	———	—
5 yr.	To use with potatoes	To sit upon	To play with	It pulls	A soldier	+
6 yr.	To eat	To sit	To carry	To run	To march	+
7 yr.	To eat	Something upon which one may sit	To play	To be hitched to a wagon	He plays music	+
7 yr.	Of iron	Of wood	Of glass	Of flesh	Has a uniform and a helmet and a saber	+
8 yr.	A handle with 3 prongs	A back and a seat and four legs	Plaything	A back and a belly and four legs	A man	++
9 yr.	A kitchen utensil	A piece of house furniture	A plaything	An animal	A warrior	++
10 yr.	An eating utensil	A piece of furniture	A plaything for girls	A mammal	A protector of the fatherland	++

III. *Copies a lozenge.*—The same may be said of this test as was said of the copying of a square. The drawing of the lines at other than right angles to each other, and at just the angle to be an approximately correct copy of the model before him, may frequently be more a test of motor ability than a test of the child's intellectual comprehension of the characteristics of the model before him. The writer has seen children with so little motor control as to be unable to make a passable copy, but who had an intellectual comprehension of the characteristics of the model such as to make them dissatisfied with their own copies.

IV. *Counts thirteen pennies.*—The mental abilities underlying the performance of this test are the same as those underlying the counting of four pennies discussed above. The difference between the two is only that of length of series. Whether or not a normal child of six is able to count to thirteen instead of ten, or any other number depends entirely upon training. The writer has found many children of kindergarten age who have been taught to count much more, some to 100.

V. *Compares faces from the aesthetic point of view.*—Six drawings are used for this test, representing heads of women. Three are pretty and three are ugly or deformed. The faces are compared two at a time, one pettty one and one ugly one, and the child is asked to tell which of the two he considers the prettier. This tests the child's comprehension of the normal or ideal type of face. That the faces would need to be changed greatly were one testing Chinese or Ethiopian children in their native home, goes without saying.

Children of Seven Years

I. *Right hand, left ear.*—The command is given the child, "Show me your right hand"; and then, "Touch your left ear." This test, at this early age, depends upon teaching. Up to this time the child has not done work of any such degree of manual skill as to bring out the distinction between the two hands. When he learns to write in the school such distinction is made. The test, if not passed, may mean only that the child has not

had such experiences as would lead him to distinguish between right and left. The writer's memory of the learning of this distinction may serve to illustrate. The knowledge was gained through the hand-shaking situation. The extending of the left hand was always inhibited by the parent's injunction, "No, give the right hand." Later in life, when there came the necessity for distinguishing between the right and left hands, it was always necessary to call to mind the hand-shaking situation, and the kinaesthetic image in the right arm which always came with it, served to distinguish the right from the left arm from which there came no such image. This method has sometimes still to be resorted to in order to distinguish the right from the left hand in unaccustomed situations.

Binet directs in his grading of this test that the child who hesitates be considered a failure in the test. But the child who hesitates for a moment and then performs the test correctly may be in some such situation as regards his knowledge of right and left hand as has just been indicated above; and this hesitation may in itself be proof that he has a control of the mental process which helps him to make the desired distinction.

II. *Describes a picture.*—For this test a picture is shown the child, and he is asked to tell what he sees in it. He passes the test if he does more than merely enumerate the objects which the picture contains. If he says, for instance, "A man and a boy are pulling a cart," and not merely, "There is a man, a boy and a cart," he has satisfactorily passed the test.

Binet finds that three intellectual levels may find expression through this test. The first occurs at the age of three when the child enumerates separately the persons and objects which he sees in the picture, without establishing any connection between them. He says, "At three years one is at the stage of recognition, or identification of objects; this is the important, fundamental work in the perception of the external world in comparison with which all the other processes of perception are complementary." The second level is that of description. This is the level of seven years. The third level is that of interpretation. "The meaning of the picture or the nature of the

people is told either by a brief word or by an explanatory remark, and often there is even an emotional note of sadness or of sympathy; it is possible that this emotional note exists with children who make a more simple response but they are unable to express it. We call these emotional responses interpretations, because they go beyond the visual impression, there is a real effort to explain the situation depicted."

Bobertag criticises Binet on two counts; 1. That pictures from which little in the way of description or interpretation could be given were used by Binet. The pictures, he thinks, were too wooden in character, too lacking in action. 2. That Binet's method of gaining response is too indefinite. It leaves the child in doubt and in a vague frame of mind as to what is wanted. Bobertag would add such questions as, "What are the people doing here? What is happening here? Why is this one doing so?" etc. In this way he would seek to guide the child into fruitful channels of response. By such methods he finds numerous grades of individual development instead of the three enumerated by Binet, but, in general, the three of Binet.

Bobertag, with his method of questioning, finds that children younger than fifteen, the position of the test for interpretation in the 1911 series, are able to make interpretations of pictures. The interpretations may, however, not be correct.

A variation of this test was used by Squire (16). She gave five pictures by noted artists, *In Disgrace,* by Sigsbeeker; *In Summer,* by Van der Veer, *Children of the Press,* by Thompson, *The Goose Girl,* by Millet and *Embers* by Eastman Johnson, to children between the ages of six and thirteen. The pictures were shown the child and he was required to give a name to each one, which he considered appropriate to the pictorial representation. There were ten children in each group. She concludes, "From these results it seems fair to say that: (1) No six-year old child can be expected completely to comprehend a situation presented pictorially. (2) Neither can a seven-year old child be expected to give an adequate title—a child of this age seems most interested in the appearance of the objects presented. (3) The eight-year old children are in-

clined to interpret meaning in terms of action, and a few are able to give superficial titles. (4) In the ninth and tenth years, while descriptive phases and activities of the object are most likely to be considered, there is, in the case of the first picture, complete comprehension of the artist's meaning. The descriptive titles, when given, are condensed into terse phrases, and no longer stretched out into disjointed sentences. (5) In the eleventh year the answers show a wide distribution, due mainly to the fact that the proportion of retarded pupils was greater in this year than any other. (6) In the twelfth year the majority of names given to the pictures would pass for titles, although a large proportion of them deal with superficial aspects. (7) There were many cases of complete comprehension in the thirteenth year. This imaginative insight could not be expected before adolescence." It is seen from this quotation that Mrs. Squire's results agree closely with those of Binet, to whose method she adhered in refraining from asking the child stimulating questions.

As Bobertag points out, the results will vary greatly with the type of pictures chosen and with the method of stimulating the child to express himself. Some of the Squire pictures are plainly not within a small child's realm of experience and are therefore uninterpretable by him. This is certainly true of *Children of the Press,* a crowd of poorly clad children receiving papers for distribution, and *Embers,* an old man seated before a grate in which the fire is slowly dying. Also *The Goose Girl* could have no associations with the experiences of a young American child not old enough to have read of foreign customs. Mrs. Squire found that the significance of *In Disgrace,* a picture of a pouting child with face in the corner, was grasped earlier and more frequently than that of any other picture. This picture certainly portrays one of the child's earliest and most significant and, perhaps, most vivid experiences.

Bobertag selected his pictures carefully with reference to the experiences of a small child, and for this reason as well as for the more stimulating method of presentation obtained a result which would lead to a more optimistic judgment of the child's

ability to interpret or abstract the meaning of a situation from the signs by which it is portrayed.

In this as well as in any others testing the child's ability to make right deductions in a given situation one must, as Bobertag pointed out, choose the conditions of the situation with reference to the child's experience. To make the sweeping declaration that a child of a certain age does not reason, from certain tests given him would probably quite misstate the case. He may reason or abstract correctly within the limits of his experience; or when the right motive for expressing his thought is supplied, as is the case in the picture test when he is stimulated by questions.

III. *Executes three commissions.*—The child is asked to listen while he is told to do something, and then the instruction is given somewhat as follows; "You see the door and the pencil and the watch; go close the door, put the pencil at the end of the table, and hand me the watch." This is a test of the child's ability to attend to a set of directions which have only a sequential relationship and translate them into activity. The test, according to Binet, is passed only if the child carries out the directions without any further encouragement such as, "And what else?"; You have forgotten something."

The writer has found many sluggish and unresponsive children who had to be encouraged in this way for one or two sets of directions, but who then would follow out other similar sets without this stimulus. One would certainly deceive himself and do the child an injustice to grade him as a failure in this test without first arousing his enthusiasm and consequent response in some such way as has been indicated. Children of the first grade fail in some cases in proper response to the school situation,—they will not attempt to carry out the directions of the teacher in games and other schoolroom activities, such as counting, writing, etc. The attitude of the teacher toward such a child and her further educational procedure with him is wholly determined by the judgment which she forms of his case. She must know whether he is by reason of innate mental defect incapable of such response, or whether his failure

is due to some other factor of disposition, emotion, will, or interest. The type of stimulus which Binet inhibits is necessary to show to what one may attribute such failure.

IV. *Counts nine sous.*—This test has for its material three objects of a value of one each, and three of a value of two each. Binet used pieces of French money. Dr. Goddard uses postage stamps, and the writer uses small squares of paper marked "1, 1," etc., since the numbers on the postage stamp are not easily discernible. The test is one of the child's ability to relate the symbols of number to the idea of number. There is involved also the idea of relative value, the value of one thing in terms of another.

The idea of relative value involved in buying and selling is one which first appears at some time between five and seven years.

If so much of number work as this test involves is taught in the first grade, the majority of children seven years of age will be able to pass it. If number work is delayed until the second grade, as is the case in some schools, many children seven years of age will be unable to pass the test. The use of tests similar to this is discussed in a later chapter.

V. *Names four colors.*—This tests the child's ability to abstract a quality and name it. The colors red, green, yellow and blue are to be recognized without error. The writer finds no such refinement of method as is insisted upon by Wallin (17) necessary. He directs that saturated colors and dull, not shiny, surfaces be used in the test. If a child knows red as a quality he knows it whether associated with a dull or a shiny surface. If the character of the article whose color he is to name interferes with his recognition of the color—though the writer has never found so anomolous a case,—it would certainly be proof that he did not know the color.

In order to relieve the situation and test of any air of formality—which is always a desirable thing to accomplish in an examination—the writer is accustomed to ask the colors of any objects at hand which happen to be of the required color sufficiently saturated and in sufficiently large masses of solid

color, such as the color of the book lying before him, the pencil which he is using, etc. The writer finds this test possible for children younger than seven. The ability to distinguish colors exists earlier than the age of seven, but its expression depends upon training. This is shown by the fact that kindergarten children are trained in the recognition of colors, and normal children of kindergarten experience know them.

As was pointed out by Binet, the naming of colors is a step in advance of the discrimination of them. Many defective children can not name colors correctly but can correctly sort color cards.

Children of Eight Years

1. *Compares two remembered objects.*—Binet says of this test: "This is a valuable test because it does not depend in the least on instruction, and brings into play the natural good sense of the subject. It consists in investigating whether the subject can, in thinking of two objects, distinguish a difference between them; the perception of the difference is, in fact, the habitual and most natural result of the comparison."

In this test one says to the child: "You have seen a butterfly, have you not?, and you have seen flies. Tell me how is it that they are not alike. How do you know them apart when you see them at the same time?" In the same way he is asked to tell the difference between wood and glass, and paper and cloth. The child is expected to give what constitutes some significant difference between the two objects, such as, "The butterfly is larger than the fly"; or, "has brightly colored wings and the fly has not." The types of response observed to this test by Binet, Bobertag, and others, are: 1. The child maintains silence. 2. He gives an answer which involves no discrimination, "Because they are different," or "Because it is a fly and one is a butterfly," or "They have wings." 3. He gives some non-discriminating differences such as "Wood is thick and glass is thin," or "Paper is whiter than cloth." 4. He gives a correct answer for the first pair asked and, finding that answer receives approval, uses it for the other pairs

and cannot be induced to make the correct discrimination for any others. 5. He gives a correct and discriminative response.

Bobertag adds to this test one which requires the child to give the characteristics in which two objects are alike. He uses sun and moon; glass and ice; honey and glue. He says to the child: "The sun and the moon are alike in something, are they not? How is it that they are alike?" The correct answer is to the effect that they are both round, or that they both shine, etc. Bobertag finds that the test for differences and the test for likenesses show that the two abilities differ in many cases. Some children are able to pass the one and not the other.

II. *Counts backward to 1 from 20.*—In this test the child is asked to count from one to twenty, and then he is asked to count backward from twenty to one. The test is one of the child's ability to rearrange mental content in a new and prescribed way. It shows that he is able to control his associations in such a way as to produce a desired result. Reciting the months of the year and the alphabet backwards are analogous and perhaps more difficult tests. The difficulty of such a test depends largely upon the familiarity with and length of series.

Binet considers the test passed if the child takes not more than twenty seconds for the process. In the opinion of the writer the time required should not be so rigidly dictated. Binet also considers the test a failure if the child can be detected counting forward up to the desired point in order to get the next item of the reconstructed series. The writer's introspection at doing this sort of thing shows that there is no other method of doing it, unless the series is so familiar as to make this method of getting the next desired item unnecessary, or as to so shorten the process as to make it seem to be altogether eliminated. With the writer the alphabet is not so familiar a series as to make this method, when repeating it backwards, unnecessary. The child who is able to hit upon such a method of doing his work and to keep his mind to the task so that he makes no errors; who does not forget that his task is to count backward and to inhibit the counting forward association, shows

his ability to control his mental processes, and has surely passed the test.

Defective children of this age are either unable to understand what is required of them, and reply with absolute silence, or can find no method of doing the work even though they do understand what is required and make a valiant effort. Some defective children who do understand what is required and who have a method for doing it, are unable to inhibit the usual counting forward association, and after one or two successes at getting the desired items for the new series, begin again to count forward. The performance in such case becomes as follows: *nineteen, eighteen, seventeen, sixteen, seventeen, eighteen, nineteen, twenty- twenty-one, etc.*

The test is, in the writer's experience, one that can be passed by children younger than eight years of age, in case the series used is one with which they are perfectly familiar. Kindergarten children who can count to ten or any other number, can also successfully count backward in the series with which they feel a perfect familiarity. Some of the kindergarten children of those examined by the writer, who could count to twenty, failed to count backward from twenty but succeeded in counting backward from ten, because the series between ten and twenty was not so familiar to them as to have become automatic, and they could not so divide the attention between the task to be accomplished and the imperfectly acquired series.

III. *Indicates omissions in pictures.* Four pictures are shown, each lacking some elemental part of the physical make up, and the child is asked to tell what is missing in the picture. This tests the child's ability to compare the representation of a type with the type itself; in this case the human body.

IV. *Gives day and date.* In this test the child is asked to give the day of the week, the month, the day of the month, and the year. An error of three or four days is allowed.

That this test may be passed two conditions are necessary. The subject must possess an appreciation of the conception of the measure of time involved in the date, and he must engage in such activities as make use of the date, such as the writing

of letters or the reading of the daily papers. A subject may fail to pass the test merely because he does not engage in such daily occupations as require note of the current day, though he is quite capable of the conception of time measure. On the other hand he may be able to recite the date without possessing any idea of the time measure for which it stands. In the school children are frequently required to place the date on written work. In such case large groups of children may know the date without the corresponding idea of time measure. In order to determine whether the child's knowledge is only the result of such specific teaching or whether it is related to the time conception, the test may be extended by asking the questions, "What day of the week was yesterday? What will be to-morrow? What was last month? etc." Many defective children are able to recite the days of the week, the months of the year, and give the date without being able to answer the foregoing questions correctly. Occasionally a child fails to pass the test according to the standard set by Binet, but is able to answer these questions correctly with reference to the date which he has given. Such a case should be given full credit for the test.

Binet says, "We found that in the schools 'maternelle,' a language lesson is given every day at the opening of school in which the day and date are taught. The children are told the day, date and year, and then made to repeat it. However, not one child in the school was able to give us the complete information, nor one the name of the year alone; and for the month many answers were given, even when in reality it was February 8. . . . It is a curious fact that children fail most often to give the year. They give no year, they remain silent for they do not know it. Perhaps a year is for them so great a lapse of time that they can form no idea of it."

If Binet's finding concerning this test and the fourth of the nine-year-old tests in which the child enumerates the months of the year are true for the ages under which they are put, one must conclude that the child who knows the day and date at eight years of age, but cannot know the months until he is nine years of age, is able to pass the former test only because

of specific training. If he cannot know the months of the year until he is nine years of age, how can he have a conception of the time measure for which the date stands?

V. *Repeats 5 digits.*—The simplest and most effective way of giving this test is as follows:—One says to the child—"Listen!" and when he is attending "2, 7, 1, say it." When he has responded correctly one says again, merely keeping the same attitude of attention toward the child, "4, 9, 6, 3," and so on until he fails. Should his attention at any time wander, it is most quickly brought back by the short command, "Listen!"

An added feature of this test is to discover how many repetitions of the set of digits, which is just beyond his memory span, is necessary before he can learn to repeat it. If the child can repeat only four digits, then a set of five may be repeated again and again until he can repeat it correctly. This gives some indication of the child's ability to take on a new habit of attention, or to advance to a higher stage of ability.

The writer finds frequently a type of defective child who, when given the set, for instance, 3, 5, 9, 1, 4, will repeat all the digits but in some inverted order, such as 3, 9, 5, 1, 4. One says to the child, "No you did not say them correctly. Say them just as I do," and they are repeated for him again. He, however, persists in saying them in the order in which he first said them. It seems, that having made one set of associations he is unable to break it up in favor of another. Upon one occasion a teacher, hearing this type of response, said of the child "That's just the way he is in reading. If he ever pronounces a word wrong, it is very difficult to get him to give the correct pronunciation." The writer has observed, in addition, the following types of response on the part of defective children. 1. They maintain silence. 2. After the child's limen is passed, he repeats only the last one or two digits of the set given him. 3. He repeats a set of numbers which may not be at all those given him. 4. He starts out with one of the numbers which has been given him, the first or the last perhaps, and then goes on counting in serial order.

Bobertag has found that children of five years of age can

reproduce a group of four digits; at seven years of age a group of five; and at ten years of age a group of six. He adds to the test, after the child's response, "Was it right?" to which the child answers *yes* or *no*. He finds that feeble-minded children maintain that what they have said is quite right, even though quite unlike the set given them. The normal child is more likely to say, "I do not know," or "It may be wrong."

Children of Nine Years

I. *Gives change from twenty sous.*—This test depends both upon ability, teaching and experience. The writer has not found the elaborate refinement of method described by Binet for this test a necessary condition for its proper performance. It is quite sufficient to ask the child to tell what would be the change that one would receive, and then, if he has answered correctly, to tell in what kind of pieces one might receive it. When a quarter is used, and the amount purchased is four cents, the child who answers correctly does not fail to tell you that your change might be in the form of two dimes and a penny. As a test of mathematical knowledge this one does not test the maximum mathematical ability of the child at this age, since the school requires more complex problems of him in the grade in which he normally belongs at nine years of age than the test implies. It is a test in which experience of a specific sort enters very largely in determining the type of performance. Many children who fail in doing the mathematical work of the school, but who are permitted to use money, are able to make change so far as their specific experiences with money permit them to do so. A thirteen-year-old defective boy in the third grade in school was unable to do the arithmetic work of the third grade. He could not learn to subtract or multiply. He, however, could make change with larger denominations and in more complex situations than this test calls for. He had learned to do this through collecting fares in the cab which he drove from his father's small hotel to the railway station. He could tell how much thirteen twenty-five cent fares amounted to, and yet was unable to so generalize his mathematical experience as to be

able to work out this or other problems with which he had no experience, by the use of the mathematical processes taught in his grade. The children of his grade can work out problems with which they have had no specific experience. They can apply the arithmetic of the school for the purpose.

II. *Defines in terms superior to use.*—Discussed above.

III. *Recognizes all the pieces of our money.*—This test is, perhaps, in its implications of innate ability not different from that one in the fourth year list in which the child is asked to name different objects. To be sure, the distinguishing differences between two pieces of money may be very much finer than the differences between a key, a knife, and a penny. Whether or not the child at this age knows these particular pieces of money depends upon the same ability which enables him at four years to name objects of any other kind, plus the specific experience which enables him to name different coins.

The writer has not found it necessary to show the child all these pieces of money in order to determine whether or not he is able to recognize them. The child who can recognize them is able to tell you in what respect a five dollar bill differs from a one dollar bill, or a silver dollar from a half-dollar, sufficiently well to show his acquaintance with them.

IV. *Enumerates the months.*—The ability which underlies this test is not different from that which enables the child at an earlier age to learn the counting series. The difference is merely one of specific instruction, plus whatever difference there may be in the difficulty of learning the two series. Whether or not the majority of children are able to repeat the months of the year at this age depends upon the school curriculum. The table of time measure is taught in that part of the arithmetical course which takes up other tables of measurement. In the Chicago schools this occurs in the fourth grade. Children who begin school at six years of age and progress normally, one grade every year, are in the fourth grade at nine years of age. It is probable, since much use is made of the date before this grade, that the names of the months of the year have been learned before this time. At any rate, the majority of children nine years

of age during the first half of the year in the fourth grade learn the various tables of time measure, including the months of the year, if they have not previously learned them. If this specific bit of instruction came at an earlier or later period than this in the school, it would not, of course, be a suitable nine-year-old test; and for that reason it cannot be considered a test of innate ability alone. The most important consideration with this test is the conception of time involved.

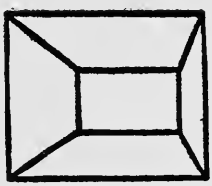
It is characteristic of defective children, who can repeat the months of the year, that they cannot do it upon the demand, "Say for me the names of the months of the year." They remain silent, not knowing what is wanted. If one starts them out, however, with, "January, February, go on now, say them for me," they can begin and repeat them correctly. In this case they have been able to learn a series, and when it is started for them they can go on with all of its terms but have been unable to relate the series to another conception. They have no idea of the meaning of the series as a measure of time.

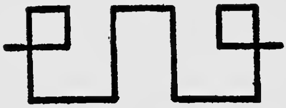
V. *Understands easy questions.*—The questions are, (1) "What would you do if you missed a train?" (2) "What would you do if one of your playmates should hit you without meaning to do so?" (3) "What would you do if you broke something belonging to someone else?" The answer to the first one of these questions depends upon the specific experience of the child in this particular situation. Binet considers the answer to this question, "Go home again," as incorrect; but in many instances this is what is done. Just what one would do of course depends upon circumstances. The child whose family would have small choice of trains, say only one a day, has observed that they do go home again if the train is missed. Question number two shows the child's understanding of the relation of conduct to motive. Question number three shows his understanding of the accepted moral way of meeting the situation.

Children of Ten Years

I. *Arranges five weights.*—The weights are in the form of boxes or blocks of identical size and color weighing respectively three, six, nine, twelve and fifteen grams. The child is asked to arrange them in the order of weight. This tests, in addition to the ability underlying the weight test in the five-year series, the child's ability to distinguish small differences in weight. In the writer's opinion, the grasp of the idea of arranging them serially, and an intelligent attempt to do so, is the significant part of the test. An error in the arrangement, such as *fifteen, twelve, nine, three, six,* is of little or no importance in judging his general intelligence.

This test was given by the writer to a college class of twenty students. Each person was given all the time that he desired to arrange the weights to his satisfaction, and was permitted to lift and test them in his own way over and over until he was satisfied that he had arranged them correctly in the order of weight, from the heaviest to the lightest. Of these twenty college students, ten arrived at a correct result and ten of them did not. The ten who failed had some such error as is indicated above.





II. *Copies drawings from memory.*—The child is asked to reproduce from memory two drawings after being allowed to look at them for ten seconds. One says to him, "I shall now show you two little drawings which you may look at for only a little while. When I take the drawings away, then you are to draw them as well as you can remember. As you have only a few seconds to look at them, you must be careful to look at both of the drawings." When the child is ready with his arms and pencil in position and attention alert, the drawings are

exposed for ten seconds. This test is one of a particular type of memory,—the visual. Psychological investigations of different types of memory, visual, auditory, etc., go to show that they vary in ability with the individual. It is reasonable to suppose that children of the same degree of general intelligence might vary considerably in their ability to pass such a test as this, unless the drawings are so simple that they come within the lowest range of ability at visual memory, or the time of exposure so long as to place them within the lowest ability at learning the drawings. This learning may consist in getting a very thoroughly stamped visual image; or it may consist in transferring the visual imagery into terms of other imagery; or the visual imagery may be partially aided or propped up, so to speak, by a partial transference into other types of imagery. Many intelligent children show that they have a method of aiding the visual memory. Sometimes it is with a verbal analysis of the drawings before them. They will say softly to themselves of the second one, "three squares in a row" and then proceed to draw the figure more or less accurately, often with the right hand square turned outward or the middle portion closed. Of the first figure one often has evidence in the result that the drawing has been interpreted. The child says softly "a box," and then reproduces the figure, sometimes correctly. Often the figure is reproduced as the conventionalized box, which shows even if one did not hear the child pronounce the word, that he has so interpreted the figure, forgotten the figure itself, and produced his interpretation.

A clear example of the necessity for aiding the visual imagery with a verbal analysis was shown by a boy of thirteen. The test was given him in a way different from that prescribed by Binet. One figure at a time was exposed for three seconds and he was required to reproduce it. If wrong, it was exposed again until such time as it was reproduced correctly. Of the second figure, he said softly to himself, "three squares in a row," and reproduced the figure correctly, except that the center portion was drawn as a closed square. He was told that he had remembered it wrong and might be permitted to look again. With

the second exposure, he said, "the center one is open," and then reproduced the figure correctly. When shown the first figure he said, "two squares," and reproduced the figure with the enclosed square in the exact center of the outer one. Upon the second exposure he reproduced it correctly. When asked what he thought about it then, he said, "I said to myself the middle one is nearer one side."

Many children aid the visual memory by outlining the figure in the air while observing it. In the writer's experience, the defective child never learns consciously to help out his defective memory with such an analysis. He may or may not learn to represent the figures correctly, after an indefinite number of exposures, but there never is evidence that he finds another type of mental imagery to aid the visual.

III. *Criticises absurd phrases.*—The absurdities are: (1) An unfortunate bicycle rider fell on his head and was killed instantly. He was taken to a hospital, and they fear he will not recover. (2) I have three brothers, Paul, Earnest, and myself. (3) I am taller than John, John is taller than Henry, and Henry is taller than I am. (4) There was a railroad accident yesterday, but it was not a bad one; the number of dead is only forty-eight. (5) Some one said, "If I should ever grow desperate and kill myself, I would not choose Friday, because Friday is an unlucky day and might bring me unhappiness."

The performance of this test requires the ability to hold in attention the several elements of the verbally presented situation, and to form a judgment as to the possibility of their simultaneous presence in the situation. The writer's experience with this test, as may be seen in the tables II, III, IV following, indicates that children younger than ten years of age are able to do this. To determine this fact, care should be taken, in giving the test, if the child answers incorrectly, to find if he is unable to hold the various elements of the situation in mind sufficiently well to form a judgment, or if he has forgotten or failed entirely to notice some of the elements of the situation as presented to him. It is the practice of the writer when a wrong answer is given to ask the child to repeat the thing that

was said. Frequently he has failed to take note of some of the elements of the situation; for instance, in the first one he sometimes has forgotten immediately that the unfortunate bicycle rider was killed instantly, in which case he says that there is nothing wrong with the statement. It is then repeated for him and he is asked to repeat it until he can do so correctly. It is only then that a wrong response can be attributed to defect of judgment. The defective child may, however, never be able to get all the elements of the situation in the field of attention at one time. Of the normal children tested none required more than a third repetition.

Among foreign children it is very common to find that they make use of such an expression as, "I have three brothers, Paul, Earnest and myself," with correct comprehension of the meaning. Their meaning is, "There are in my family three brothers"; but the putting of the statement in the first person does not show a lack of judgment on their part. It is merely a very common misuse of language on the part of foreign speaking people.

IV. *Understands difficult questions.*—The questions are: (1) What should you do if you were delayed in getting started to school and knew you would be late? (2) What should you do before taking part in an important affair? (3) Why is a bad action done when one is angry more excusable than the same action done when one is not angry? (4) What would you do if you were asked your opinion of someone whom you did not know well? (5) Why should one judge a person by his acts rather than by his words? These questions test the child's ability to formulate a rule of action to meet a given situation.

From the answers one can often determine whether the child has generalized the situation or has in mind a particular situation. To question number one, Binet considers only the answers, "I should have to hurry or "I should have to run," as correct, the idea being to reduce the amount of tardiness. However, the rule or practice adopted by the particular school or the home may determine another answer which would be equally correct.

For instance, if he says, "I would go back home and get an excuse from my mother," since some schools make this requirement. The second question the writer finds it necessary usually to put in this form: "What ought one to do before beginning a very important piece of work or anything that is very important?", since the word *affair* among uneducated classes is not understood. Some children generalize the situation, and answer to the effect that they would think or reflect about it. Some children have in mind particular important situations, usually those in which they have recently engaged, and answer accordingly. One girl, thinking of a fine piece of embroidery which she had been doing for days in the schoolroom for a rather important purpose, answered, "Wash your hands." A boy, thinking of a workshop where he had been for several months learning a trade, said, "Ask the boss to show you how." The generalized form of answer shows a higher range of intelligence than the particularized form. Young children and defective individuals are, if they answer at all correctly, more likely to particularize the situation than to generalize it.

V. *Uses three given words in two sentences.*—Binet uses the words, *Paris, fortune, stream;* Dr. Goddard uses the words, *Philadelphia, money river;* The writer uses the words, *Chicago, money, river.* Binet says of this test that it shows the child's ability to invent his own expression. He directs that the child be asked to write the sentence or sentences which he makes. The writer's practice is to ask the child to give his sentences orally. With very young children the word *sentence,* is not understood, and the child is asked merely to tell something about these three things, or to say something that has these three words in what he says, or to tell a story about them.

The success of the test with children of different ages depends upon the words chosen. When there is a failure to respond with a correct sentence for the words *Chicago, money, river,* the writer gives other words, such as *boy, river, ball,* when the result is generally successful with normal children. This indicates that the ability to invent one's own expression may be something apart from the ability to invent an expression for a

given set of words. Success with certain sets and failure with certain other sets may indicate, among children of the same or different ages, differences in experience, or maturity of thought, but one would have to examine further than the set given by Binet before deciding that the child lacked the ability to invent his own expression.

Young children fail to respond to the words *Chicago, money, river,* because their experiences with such generalized ideas as these is quite lacking; or in their specific experiences, the three ideas expressed by these words may never have had any relation to each other and the child is therefore unable to form a train of ideas which would connect them all. When he is given a set of words which come within the experience possible to his age, he is successful in his response.

Illustration of the influence of formal educational experience was furnished by the children whose records appear in the tables below. In the local history which is taught to the third grade, the Chicago river figures much in the development of the city of Chicago. The children from this grade gave generally a sentence which expressed this historical fact,—in effect, "Chicago has a river which cost much money." The children of the other grades did not generally give this sentence.

Another type of sentence is one which is grammatically correct but is an invention merely to fulfill requirements, such as, "Chicago has a river, and also much money in its banks." This type of sentence is given very largely by the child who lacks the historical teaching just mentioned. A third type is nonsensical in meaning, such as, "Chicago makes more money than the river does," a sentence given by a fifteen-year-old defective girl. Squire (16) gave the set, *boy, river, ball,* to six-year-old children with the requirement that they tell a story. She obtained a uniform result showing that the child of this age is able to invent his own expression.

Children of Twelve Years

I. *Resists suggestion.*—The material for this test as prepared according to Binet's suggestions, is: "Prepare a booklet of

six pages. On the first page two lines are drawn in ink, A and B; the first, that is the one on the left, is four centimeters long, and the second five centimeters; they are placed in line with each other and one centimeter apart; on the second page two similar lines are drawn, the first five centimeters, the second six; on the third page the first line is six centimeters, and the second seven; on each of the three following pages two lines are drawn in the same positions, but all are the same length, seven centimeters."

In giving the test one says to the child, "Which is the longer of these two lines?" (showing the first pair), "and of these two?" (showing the second pair), and so on. Many children attempt to measure the lines; if not directly on the page itself, in some other way, by placing the fingers appropriately on the table before them. For this reason the writer finds it advantageous to say to the child, "Which of these two lines *looks* the longer?" Binet finds that children under twelve years of age tend to answer correctly for the first three pairs, and to make the same answer for the next three. That is, the child points for the first three pairs to the longer line at the right; he has thus established a "habit," and follows the suggestion given for the next three pairs by pointing also to the ones at the right.

Binet has not in his discussion of this test mentioned the fact that frequently the wrong judgment on the part of the child is not the result of the type of suggestibility which this test is designed to measure. This error in judgment occurs frequently under such circumstances as to make one doubt that it is the result of habit plus suggestibility. If the child pauses for a moment before the two lines of equal length, looks at and scans them carefully, and then indicates one as being longer than the other, the error is very apparently not the result of "habit" and "suggestibility." It shows that he has used his judgment but has judged incorrectly. The writer's experience with this test may throw light upon the child's error. When looking at the two lines intently and moving the eye from the left-hand end of the left line to the right-hand end of the right

line, the left line appears to be the longer. Many of the children to whom this test was given made this particular type of wrong judgment. The number is indicated in the tables which follow. Those who made the error in such a way as to conform with Binet's interpretation of it, that is, said the right hand line was longer, were marked failures in the tables. The writer also tried this test upon six adults who came into the clinic one after another on a certain day. All of these persons made wrong judgments, at least to the extent of saying that they thought the left line was longer than the other but were not quite sure about it.

II. Cf. above, test five, under ten-year-old children.

III. *Says more than sixty words in three minutes.*—The child is asked to say as many words as he can think of in three minutes, and is told that they will be counted. Binet says, "This test is very interesting, for its fertility in suggestions. Besides the number of words, one can know their relation. Some subjects give only detached words, each of which requires an effort to recall; others give a series of words, the furnishings of a school, various articles of clothing, geological terms, etc. Some use only names of common objects, others cite abstract words or rather far-fetched words. All this gives an idea of the mentality of the subject. The use of series of words, and of abstract terms, indicates a certain amount of intelligence and culture. . . . By this test we are able to estimate, according to observations which we have made elsewhere, both the intellectual activity of an individual and his verbal type."

In addition to the above phases concerned in the judgment one may derive from this test, another may be considered. In the writer's opinion, a certain paucity of words in the performance of this test with young children does not necessarily indicate a low level of intellectual activity; indeed, it may indicate a high level. In the conversation of every-day life words come not singly and unattached, but are the result of associations which the purpose of the conversation brings about. Other associations than those pertinent to the subject of discussion are inhibited by the normal person. Without a purpose for the

use of words they may not occur in association. Many children like to comment upon their successes with this test and tell how they accomplish it. One said, "I thought about all the things that we have on our boat, and named them all." Another fastened his eyes on a map on the opposite wall, and mentioned all of his observations associated with it. Many of them make the comment, "It was hard to think of the words." All of this comment on the part of the child shows the necessity for an object and a use for the word before associations with other words can be made.

IV. *Defines abstract terms.*—The terms to be defined are: *charity, justice, kindness.* See III, under adults.

V. *Derives the sense of a sentence the words of which are mixed.*—A card is given to the child with the words, *For—an—the—at—hour—early—we—country—started.* The child is told that here are the words of a sentence which were mixed up, and that if he puts them in the right order he will make a good sentence. This test is discussed further on page 72.

Children of Fifteen Years

I. *Repeats seven digits.*—This test is made in the same manner as that which requires the repetition of five digits. In the writer's experience with it most children who succeed are those who after the first or second failure repeat softly to themselves the digits as they are given by the experimenter. This provides the child with an added memory image to aid in recall.

II. *Gives three rhymes.*—The child is asked to repeat as many words as he can think of that rhyme with the word *obey.* The writer's experience with this test shows that the success attained with it depends upon the word which is chosen. Younger children will readily construct a rhyme with the word *hill,* for instance, but remain mute when given the word *obey.* The two-syllable and more unfamiliar word presents to their minds difficulties which they do not attempt to surmount. The same child, however, will glibly recite hill, fill, will, etc., when given the more easy and familiar word.

III. *Repeats a sentence of twenty-six syllables.*—The child is

told that the experimenter will repeat some sentences to him, and that he is then to repeat them exactly as he has heard them, without the change of a single word. The writer's experience shows that success with such sentences is dependent upon the familiarity of the child with the words used. An unfamiliar word or name so attracts the child's attention from the remainder of the sentence that he is unable to give it. When giving such tests to children of foreign parentage it has been found expedient to use the vernacular to which the child is accustomed. For instance, in the following sentences: *The other day I saw on the street a pretty yellow dog; Little Morris has stained his nice new apron.* Among children of the street type frequently encountered *Morris* is sometimes an unfamiliar name, *stained* is always an unfamiliar word. The test is passed better by these children if these words are changed in such a way as to make the sentences seem very familiar to them. In the following sentence,—*"Ernest is frequently punished for his bad conduct"—frequently* is a word which the street child has probably never used, even if he has heard it. It is expedient to change it to a word familiar to him in his own vocabulary.

IV. *Interprets a picture.*—See above.

V. *Solves a problem from several facts.*—The two situations presented to the child are: (1) *A woman walking in the forest of Fontainebleau stopped suddenly, dreadfully frightened, hurried to the nearest policeman and told him that she had just seen hanging to a limb of a tree—what?* (2) *My neighbor has just received some singular visitors. He received, one after the other, a doctor, a lawyer and a priest. What is going on at my neighbor's house?* These situations are presented to the child in such a way as to conform with circumstances familiar to him. The name of the park nearest his home is substituted for the *forest of Fontainebleau.* In the second situation, with Protestant children *minister* is substituted for *priest,* and with Jewish children *Rabbi* is substituted. The writer has considered it expedient to allow credit for answers to the first in addition to the one which Binet permits. Binet judges the only correct

response to be, *"A person who has been hanged."* The answer sometimes is made. In addition, one often obtains the answer, *"A wild animal."* Under the circumstances, this is in the child's mind sufficient reason for the conditions of the problem. In the city of Chicago one of the large parks contains a menagerie. There occur occasionally in the newspapers stories of the escape of animals from the menagerie. That these stories are always untrue, of course the child does not know. Another answer which has been given so many times as to show the application of real experiences to this situation is, *"An owl; his eyes frighten you and make you think something dreadful is there."* For the second situation, the writer has found it expedient to add an additional caution. If the child answers correctly, "He is ill," or "He is dying," he is asked to tell why in that case the three people have gone there. Frequently the child's correct judgment is made with reference to one of the conditions only, that the doctor has gone there. He does not know why the lawyer and the priest have gone, which shows that he has not taken into account the whole situation. His answer, even if correct, is given such credit only if he can give correctly the functions of the lawyer and priest in the situation.

Adults

I. *Solves the paper cutting test.*—A sheet of paper is folded along both diameters before the subject and a small triangle is cut out along the edge which shows but a single fold. The subject is asked to draw on a similar sheet before him the position of the cut out portion when the sheet is unfolded. This test requires control of the mental imagery in accordance with the given conditions, such as to bring about in imagination the correct result of the conditions.

II. *Reconstructs a triangle.*—A card is cut in two pieces along the diagonal. The pieces are placed before the subject on a sheet of paper, and he is asked to draw the resulting shape if the lower piece is placed in such a way that the short side lies along the diagonal of the other card with the right angle at the left-hand corner of the upper card and the end of the

long side pointing downward. One says to the subject, "How will it look if I place the lower card so that this edge lies along this edge, with this corner here, and this one pointing downward?", with the gestures appropriate to the above explanation. This test, as the one above, is one of control of the imagery to correspond with the given conditions, with a concrete stimulus to set up the train of imagery.

III. *Gives difference in meaning of abstract terms.*—The question is asked, *What is the difference between laziness and idleness; between event and advent; between evolution and revolution?"* The passing of this test depends, of course, upon the training which the subject has received. Except among educated classes in America the word *advent* is unusual, as is also the word *evolution.* An example which illustrates the dependence of this test upon training is the answer of a twelve-year-old Catholic boy in the high school. He said, "Advent is a church festival; evolution is a term in arithmetic." Both these answers were correct, though strictly they could not fill the conditions of the test. Many children say for *revolution,* "It is a turning about," often giving as an example, "A wheel revolves and then there is a revolution." This, to be sure, is correct. Many children give as a definition for *revolution,* "It was a war," which, with reference to American history, is also correct.

That there is a difference in innate ability between the persons whose acquaintance with the words has been somewhat limited and who, therefore, gives a limited definition but entirely correct within the realms of his own experience, and the older or better educated person who gives a definition for the words also correct within the realms of his larger experience, is problematical. If the two are of the same age but the education of the former was cut off at such a place that further experience with these words was prevented, one may not rate him upon this test with less innate ability but with less education.

IV. *Solves the question concerning the president.*—The question is, *There are three principal differences between a king and a president; what are they?* This test also depends for its proper performance upon the education of the subject.

V. *Summarizes an observation made by Hervieu.*—The child is told that a short paragraph will be read to him, and then he is to tell in his own words the meaning of it. The paragraph is: *Many opinions have been given on the value of life. Some call it good, others call it bad. It would be more just to say that it is mediocre; for on the one hand our happiness is never so great as we would have it, and on the other hand our misfortunes are never so great as others would have them. It is this mediocrity of life which makes it just, or rather which prevents it from being radically unjust.* This tests the ability to control the attention over the period of the reading of the selection and to generalize the abstract thought which it contains.

IV

FALLACIES AND INADEQUACIES OF THE BINET-SIMON SERIES

From the use and analysis of the Binet-Simon tests one realizes that the theory underlying their construction was not clearly conceived by their authors or was not consistently carried out.

The method used in the first series was that of putting to children of different ages a large number of questions and setting down as suitable to each age those questions which received at a given age a certain percentage of correct answers. The 1908 series, which has received the largest use, contained a reading test. In the 1911 series this reading test with a few others of less importance were eliminated in order that the series might be free from those tests which are the product of educational advantage. Because of these considerations, then, the series may be accepted as designed to measure intellectual growth from year to year without reference to the changes produced by formal instruction.

Though Binet nowhere definitely outlines his theory one gains the impression that the different age groups of tests are designed to measure something in mental development which is qualitatively different from year to year. One infers from various statements that certain tests are possible at nine years of age, for instance, which were not at eight because of a certain quality of the nine year mental age not possessed by the eight year mental age. In other words the assumption is that there is a mental growth from year to year which makes it possible to take on at corresponding ages certain experiences without reference to previous experience. For instance, at a certain age it is possible for the child to know the months of the year, at another age he cannot. That is, this underlying factor of mental growth determines the form of expression of mental life. The converse of Binet's theory is that the form of ex-

pression of mental life at any time is determined by the sum of previous experiences.

The theory of Binet may be expressed as follows: at a certain chronological age the mental age may be represented by x, at a succeeding chronological age it is y, and at a third it is z. According to the converse theory, the mental age of the first period, is x, at the second $x + 1$, at the third $x + 2$. A third possibility presents itself. At the earliest measurable stage of development the mental age is x, at the second it is y, and at a third it is z, and thereafter at succeeding stages it is $z + 1$, $z + 2$, etc. The unknown quantities stand for the immeasurable innate factors which distinguish the vegetative idiot from the normal person and the ordinates for the measurable factors of experience.

Apparently Binet assumed the first possibility to be the rule of development from infancy to adult age. That the assumption is true to this extent has not been proved by observation or experimentation in child psychology.

It is probable that the third possibility more nearly expresses the truth. There are, we know, periods of development in the child where great and significant changes take place, both physically and mentally. The acquisition of walking and talking mark stages of development which are of great significance in the growing child. Certainly the mind is qualitatively different after the advent of the great increase of motor ability accompanying walking, and of language. The advent of puberty marks another such stage of development. The mental changes accompanying puberty mark off a rich field for investigation. The walking stage and the pubertal stage have their bases in physiological changes which may be more or less definitely accompanied by intellectual changes. To what extent these physiological changes cause or accompany or are paralled by intellectual changes of a qualitative kind not dependent upon previous experience, is one of the unanswered problems of genetic psychology. Aside from these few possibilities we do not know whether mental development proceeds from year to year as Binet assumed. We do not yet know except in a few matters

whether a child is innately more capable of certain mental processes at one time than at another. In the discussion of the preceding pages it has been shown that some of the tests placed at certain ages by Binet and supposed to measure abilities peculiar to those ages, could be used to call out an expression of the same abilities at earlier ages if so presented as to fall within the child's range of possible experience at those ages. The interpretation of pictures, counting backward, and originating of a sentence with three given words are cases in point.

Until we know more of these most fundamental of the underlying facts of genetic psychology we can not unqualifiedly accept the Binet-Simon tests for the purpose for which they were devised, namely the measurement of mental age. We must know in more fundamental terms than they express what it means to be eight years of age, or ten years of age mentally.

We must be able, too, to separate innate mental development from that due to education of specific types. This the Binet-Simon tests fail largely to do. This point has been indicated in the foregoing discussion of the individual tests. The most striking example of this lack is the test which requires the reciting of the months of the year. The very young or the defective individual may have the ability to learn this series with more or less facility but the conception of time relationship involved in the series is one which it is possible is not entertained by either. The same thing may be said of the counting series which may be learned as a verbal series without the accompanying conception of number. Such tests as these without further investigation fail to indicate the type of mental complex involved in passing them.

It was Binet's attempt to measure only innate ability as distinguished from information, however, which led him to discard reading tests from the 1911 series.* By reason of this the series now fails to take account of a most important set of abilities, those that the school endeavors to develop. Many innate abilities can be measured only by the reaction of the individual to the learning situation. The most obvious measure of the ability or group of abilities which enables one to learn

to read is the amount that has been learned after a given period of instruction,—say a year in the first grade of the public school. The use which can be made of the school tests of reading, writing, and arithmetic is discussed below. They are valuable because, in a given situation in which the curriculum and the child's history are known, the relation of the product to the experience can be measured.

However, if we should admit that there is such development of mental age as may be measured from year to year, the Binet-Simon tests do not constitute an accurate measure of it, as is claimed by Binet and his followers. This is most strikingly shown in the work of Goddard (13) who applied the scale of 1908 to two thousand nonselected children of the public school. He made a distribution table showing the relation between the mental age as measured by the Binet-Simon tests, and the chronological ages of this group. This piece of work was discussed in 1912 (18) by the writer as follows, beginning with Goddard's table showing the chronological and mental age distribution of his two thousand subjects.

	Mental Ages												
Age	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*Total*
4 yrs.		1	2	2	3								8
5 yrs.	2	4	8	40	16	4							114
6 yrs.	1	0	3	29	48	69	9	0	1				160
7 yrs.	0	1	2	8	15	114	50	4	3				197
8 yrs.	0	0	2	2	1	87	86	16	12	3			209
9 yrs.						27	54	56	58	4	2		201
10 yrs.					3	15	24	19	124	27	8	2	222
11 prs.					1	4	13	25	50	60	12	1	166
12 yrs.						4	10	13	42	36	39		144
13 yrs.						1	5	6	30	19	21	7	89
14 yrs.							1	1	6	5	4	3	20
15 yrs.								3	0	1	2	0	6

Showing the chronological and mental age distribution of the two thousand public school children graded by the Binet tests.

The writer has computed from this distribution table the percentages of those who passed "at age" or normal, "below

* *Nouvelles Researches sur la Mesure Niveau Intellectual chez les Enfants d'Ecole.* L'A. P. 17: 146.

age," and "above age" for the different ages. These percentages arrange themselves as follows:

Age	Below Age	At Age	Above Age
5	12.2%	35.0%	52.6%
6	20.6	30.0	49.4
7	13.2	57.8	28.9
8	44.0	41.1	14.8
9	40.2	27.8	31.8
10	27.4	55.8	16.6
11	55.4	36.2	7.8
12	72.9	27.0	00.0
13	92.1	7.8	00.0

This table shows that with the exception of the seven-year- and the ten-year-old children less than fifty per cent of any group were graded "at age" according to the Binet scale. Of the eight, nine, eleven and twelve-year-old children the largest group is of the "below age" group; and of the five- and six-year old children the largest is the "above age" group. Dr. Goddard has grouped all the "above age," all the "below age," and the normal or "at age" groups regardless of chronological age and obtains a curve very closely approximating a normal distribution. Of this curve Dr. Goddard says, "The significance of these figures obtained from the general result is very great. There is every reason to believe, and statisticians confirm this, that any group of two thousand children may be taken as a fair sample of conditions to be found in any number of children to be found in any country. Consequently whatever percentages or proportions are found here may be taken to be very closely the standard to be found elsewhere." In answer to this statement we may make the very obvious objection that this curve is not made up of the measurement of one quality of an otherwise homogeneous group, but is compiled from the measure of many qualities of children of different ages. It is made up of the results of tests applied to children of different ages who may not have done the same tests, as will be presently shown. The curve can, therefore, have no statistical validity. It is merely a happy or an unhappy accident. Dr. Goddard says further, "Bearing this in mind it becomes very significant when we find that we have 78 per cent of the children practically normal and satisfactory—for we allow those children who are one year above

and one year below to pass with the central group as satisfactory children." It is only by lumping the percentages again that this approximation of a normal distribution is obtained. The percentages of those graded normal according to Dr. Goddard's standard for the different ages arrange themselves as follows:

Age	5	6	7	8	9	10	11	12	13 years
Per cent normal	77.1	91.2	80.7	90.4	83.5	76.5	73.4	52.20	31.4

This table shows that it is only for the ages five, ten, and eleven that a standard approximating that fixed by Dr. Goddard is obtained. The twelve and thirteen year group fall below, the six, seven, eight, and nine year groups above it. The adoption of Dr. Goddard's standard is, however, hardly permissible because of the great pliability of the rule for grading the tests laid down by Binet. This rule, presumably followed by Dr. Goddard, allows a child to be graded normal or at age if he misses not more than one of the tests designed for his age. If he misses two of the tests for his age he may be allowed to substitute tests of a higher age and still be graded normal. This method gives the nine-year-old children, for instance, opportunity to fail on any two of the six tests for that age and substitute any three of the sixteen remaining tests. They are then graded as nine years of age mentally. The eight-year-old children may pass any five of the twenty-two tests above those for eight years and are then graded nine years of age. The ten-year-old children may fail to pass two of the ten-year-old tests and not a sufficient number of those above to compensate and are then graded nine years old mentally. In this way we may obtain one mental age group by classing together three groups who have done different things. Dr. Goddard gives a further pliability to the method of grading by grouping together with these as normally satisfactory two other groups who have done still other things.

Further doubt is cast upon the accuracy of the tests by the fact that judgments arrived at through their application do not coincide with that of the school concerning the same subjects. Dr. Goddard, himself, recognizes this. He says, "Analyzing our data so as to show where each individual is, we find that

the case is not as favorable as we suggested in the previous paragraph, that many children who are normal mentally [*according to the Binet tests*] are two or three or possibly four years behind their grade. We find a great many other children who are mentally dull, not as far behind their grade as their mentality would require. We find still worse conditions among those who are ahead of their age mentally. They are not correspondingly ahead of their grade. In other words the two systems do not agree at all. Now having satisfied ourselves that the Binet scale is the most accurate method that we have of determining intellectual ability in children, the question at once arises, how much injustice is being done these children by the ordinary school routine?" The teachers of the school might well retort to this question that as they have the child continuously over a period of years their judgment of his abilities ought necessarily, in general, to be more accurate than that arrived at by a ten or twenty-minute examination over very little of the matter with which the school concerns itself.

Terman and Childs (15), after the application of the Binet-Simon scale of 396 non-selected children of the public school, came to the following conclusion: "It is evident from the results of our investigation that the Binet scale requires a radical revision to make it at all suitable to conditions in this country." The revision of the Binet tests made by Terman and Childs, as they point out, "has made the lower end of the Scale more difficult by setting back many of the tests of Binet's higher years, and the upper range has been supplemented . . . and some of the tests even discarded . . . Believing that tests of memory, vocabulary, observation, reasoning, and reaction to a complex social or moral situation bring out fundamental characteristics of mental ability, we have given our scattered range of tests on memory, questions of comprehension, reasoning tests involving observation, linguistic invention, and association, such as the completion test, and rearranging a sentence of mixed words, vocabulary, etc., so that a child of any age will be tested on a number of these important questions."

Daugherty (19) applied the 1911 series to 483 public school

children with the following results: 30 per cent passed at age, 18 per cent above age, 42 per cent below age. Of the 483 children, 45 per cent were in the school grade normal to their chronological age, 49.3 per cent were retarded, and 5.6 per cent were advanced. When distributed according to mental age 48.7 per cent were in the school grade normal to that age, 21.1 per cent were retarded, and 30.2 per cent were advanced.

Goddard graded four hundred institution feeble-minded with the 1908 series. He read the classified grading to the teachers and other officers of the institution and asked for criticisms upon the classification. The object of the exercise was to determine whether the individuals classed together by the Binet-Simon system would be so classed by the people who had had school and other types of acquaintance with them. The result was that no individual was considered by the majority as not belonging to the class in which his name was presented to them. One necessarily must doubt the validity of a judgment obtained under such circumstances as this. The classified list was read to the teachers. The members of this institution doubtless were already prejudiced in favor of the system adopted for use there, and in the judgment of their psychologist. Their minds were not left free for unprejudiced judgment.

Kuhlman (14) asked the teachers and other officials to grade fifty institution feeble-minded into five groups. These children graded from eight to twelve years mental age by the tests. Of the result he says, "The most striking fact about this table is the frequent wide range of disagreement of the teachers' gradings. For nine children these grades differ by four years, for nine others they differ by three years, for nineteen by two years, and for seven there is complete agreement. There can be no question about the fact that the Binet-Simon tests do not make half as frequent or as great errors in the mental ages as are included in these gradings based on careful, prolonged observation by experienced observers on this class of children. In other words, the chances for error with the tests are much less and are smaller when they do occur than is the case with the grading of any one individual experienced observer when this

grading is on the usual general observation." The answer to this objection is that there are many considerations to enter into the estimation of the intelligence of any subject, and different teachers may have had different bases for their standards of judgment. We do not know what was the standard of the individuals who passed judgment. It is possible that each teacher had in mind that subject of instruction which it was his function to impart. For one it may have been reading, for another, manual training. According to the writer's observation ability of defectives in the two subjects varies widely. The various Binet series provide no test for either,—if one takes into account the rule for grading for the series prior to 1911. The official concerned with the institution routine work may have had in mind as his standard the reliability of the child in such work. The value to be placed upon any judgment of general mental ability is proportional to the number of items taken into consideration and the weighting given those different items. We do not know in view of the disagreement whether in this case it was the judgment of some of the teachers or the rating arrived at by the use of the Binet tests which was most reliable. Since there was so great disagreement between these people who were well equipped by experience and observation to make a judgment and the tests, it is probable that the former took into consideration certain factors which might well be included in any system of mental measurement.

The extensive pieces of work upon the Binet-Simon tests quoted above show, also, the lack of correlation between the series and the child's ability to succeed with the work of the school. The Binet tests, therefore, while professing to test native ability are concerned very little with the education which all normal children have the native ability to acquire, and which is of much importance in civilized life. The school is busy during the first four years of the child's school life developing ability in the processes of reading, writing and arithmetic. In in the new series there is none at all. The arithmetic tests are: the 1908 series there was no reading test before eight years and a counting test; a test of the combination of the numbers

2, 2, 2, 1, 1, 1; and making change for a quarter. The school teaches during the years for which these tests are designed more complex processes than these. Along with and after the mastery of the early subjects of formal instruction, the school is concerned with their application, especially of reading, to the acquisition of a systematized body of information, such as geography, history, etc. We have then to conclude, that since the 1908 series falls short of measuring the abilities which the school expects to develop, the 1911 series is still more open to criticism.

In the work of the public school ability to read is of the greatest importance because upon it depends all further progress in the school. Number conceptions and knowledge of the processes of their combinations are of so great importance in the practical activities of every day life that arithmetic occupies a large part of the time of the public school. Mentally defective children in the public school display their defectiveness in their slowness or failure in acquiring the processes of reading and number work. Any set of tests which fails to explore these realms of mental activity can be of little value as a measuring scale for backward children brought to the clinic of the public school. We must conclude, then, that at least the lower end of the Binet-Simon scale does not measure the ability of a child in accordance with the social standards set for him.

The second psychological fallacy implicit in the grading of mental defectives according to mental age is seen in the false assumption that a defective individual of any age, who tests to a certain mental age according to the Binet-Simon scale, is equivalent to or identical with the normal child of corresponding chronological age. Examples which illustrate this point may be quoted from the clinical studies made by Huey (20). He says of case 22: *"In school Hilda reads poorly in the first reader, adds and subtracts very little, is poor in spelling, writing and industrial work, but dances well. She gives only momentary attention to anything, gets on fairly well with others, and her worst fault is stated to be her insistence on being the center of attraction. She is most restless and 'always sits on one leg or*

twisted around in her seat.' She appears bright, and even spontaneous, but she does not get the work done. She is over-demonstrative of her affection for persons whom she likes. The Binet tests give her a mental age of eight and one-half years, a retardation of two years. She could not repeat 16 syllables, could not count stamps, nor backward from 20 to 0, could not write a four word phrase when heard, could not give the date even approximately, nor make change, name the months, or arrange weights. Hilda has learned to write with moderate legibility, but cannot use writing to any purpose. In trying to reproduce stories I and II and to write of a trip in a flying-machine, she wrote 9, 6 and 4 lines respectively, being a hotch potch such as 'a fat pig a hoig to leand a good heven Cand a sometime cand.' etc. Instead of writing similars and opposites, in the tests for these, she either copied the words with strange transpositions and changes, or occasionally wrote some apparently unrelated word or series of letters. . She crossed 49 and 77 A's in two minutes each, with no errors. Her tapping record counted to nearly normal, but she showed exceedingly poor control, tensing her fingers into knots, hammering the key. etc." All of this description points out in a very striking way the defects of Hilda's mentality as compared with that of the normal 8-year-old child in the school. The normal child of this age can do more than read poorly in the first reader, has a knowledge of arithmetic processes such as enables him to make changes within one dollar; to recognize related units of measure, such as inch, foot; minute, hour, day, week; pint, quart; cent, nickel, dime, quarter, half-dollar? dollar; to use the tables of two's and three's; to count by two's to 24 and by three's to 36; to tell half of any multiple of two to 24 and one-third of any multiple of three to 36; to read and write numbers of one and two orders; to read time by the clock to hour, half hour, quarter hour; and to answer any of the 45 addition and subtraction facts. [According to the 1912 Course of Study for the Second Grade of the Elementary Public Schools of Chicago.] The child of 8 years *can* use writing to some purpose; he can organize his mental life with reference to this accomplishment

so that he does not produce the results which were quoted of Hilda.

Another example of this fallacy is that of Robert P., quoting from the volume mentioned above. *"In school Robert reads fairly in the first reader only, does some addition and subtraction, but failed on 5 x 2 and 4 x 1. He does well in calisthenics and likes to 'lead.' He is also good at dancing and in basketry. In manual work he is generally quite satisfactory, only working by fits and starts, though occasionally he turns in and works hard for a time. . . . Mentally Robert shows an intelligence of nine years with a retardation of five and one-half years. His speech is nasal, but he can articulate normally. He could repeat five numerals but once in seven trials, could not count from 20 to 0, nor make change of 4 cents from 25, name the months, detect nonsense in sentences, or give 6 of the 19 details about the 'fire.' He seems to be bored with the trouble of thinking. He did not make absurd replies, but was merely weak in his adaptations and at the same time rather self-satisfied with them. 'Not very hard' was his characteristic reply after utterly failing to rearrange the shuffled words of a sentence. . . . In the written tests the work is very weak both in quantity and quality. His handwriting is irregular almost to scribbling, though large and therefore moderately legible. His mis-spellings, as in some of the other cases, suggest a form of agraphia."* It is needless to point out that the normal child of nine years can do more than read in the first reader, would not fail on 5 x 2, is not bored with the trouble of thinking, and is not satisfied with absurd results, such as were mentioned in Robert's case.

In the cases described above one also sees along with the fallacious assumption which they disclose, the failure of the Binet tests, alone, to adequately describe or explore the mental life of any subject. This inadequacy of the Binet tests is strikingly shown in the description of a case which was discussed by the writer in the above mentioned article:—"But the writer feels impelled to assert that if there were complete agreement between the test findings and school grade they would still, alone, constitute an inadequate measure of mental ability or mental de-

velopment. The best possible illustration of this is afforded by the description of a boy by Holmes in a recent article. The Classification of Clinic Cases. The following is an abstract of Holme's description of the case: *The case was that of a six-year-old boy who had been in school for six months without having made any progress in the work of the school in spite of the fact that an adult sister attempted every evening to teach him his lessons for the next day; he cried when struck by his playmates or when hurt by his playthings but did not strike back or in any way try to defend himself and would run to his mother for help; he could assemble the parts of electrical apparatus, arranging cells, wires, and bells so they would ring; could connect an incandescent lamp so it could be lighted; could start and operate a gas engine by himself.* In commenting upon this case Dr. Holmes fell in the fallacy of an uncritical acceptance of the Binet tests when he said, 'It presaged what was revealed by the Binet tests, namely that the boy was one year beyond the mental attainment of the average boy of his age,' that is, he had passed the Binet tests for seven years. In the case of this boy were found by Dr. Holmes four distinct judgments. His sister and the school thought him a dullard; his father, with whom he worked at the electrical apparatus, thought him all right; his playmates considered him a mollycoddle; and the Binet tests classified him as somewhat precocious. No two of these judgments were the result of the same set of data. The school judged him by his proficiency in acquiring the processes of reading, writing, and number conceptions; the Binet tests have nothing to do with these school abilities except counting to thirteen and writing from copy in the seven-year-old tests, in either of which he may have failed and still be graded one year ahead of his age. Neither is there in the Binet tests anything which would hint at or indicate his ability with mechanical contrivances; nor that his social reactions would be as they were. Should the school and social disabilities be persisted in through life or for several years he certainly would not escape being considered a defective. It is also clearly indicative of the inadequacy of these tests that Dr. Holmes could not give a description of the case in terms of their result. He

had to resort to other facts in order to present a true picture. We certainly can not agree with him that this boy had the mental attainments of a normal boy of seven years. In that case we should have to believe that the majority of seven-year-old boys possess his mechanical efficiency and his academic inefficiency, which is not true. Children of six can learn to read and if children of seven can assemble the parts of a gas engine and run it without adult supervision no one knows it. In the case of this boy there was one and possibly there were two of his social relationships in which he failed to function properly, namely, in his reaction to the school and to his playmates. It would seem to be the legitimate business of the psychological clinic to find why he thus failed. Was the defect in his school work due to a lack of ability for that type of activity, to lack of interest in it; or was it a result of his defective social response? And what was the cause of this latter defect?

Another case showing the inadequacy of the Binet tests to describe a case of mental defect was described by the writer in the above mentioned article as follows: "This case was a boy, Frank, aged sixteen. Following are his reactions to the Binet series copied from the notes of the writer made as they were given.

Eight Year Tests:

1. Comparison of butterfly and fly, etc., passed.
2. Counts backwards, passed (?) (Forgot where he was once and had to ask what had said last).
3. Notes omission eyes, etc., passed.
4. Date, failed.
5. Repeats five numerals, passed (once out of three trials).

Nine Year Tests:

1. Makes change, passed (25 cents—9 cents. Instead of making the change told that one could receive it in the smallest number of pieces in a nickel, a dime, and a penny).
2. Definitions superior to use, failed.
3. Recognizes money, passed.
4. Months of the year, failed.
5. Problem situations, passed.

Ten Year Tests:

1. Arranges weights, passed.
2. Copies design, passed.
3. Detects incongruities, failed.
4. Problem situations, failed.
5. Three given words in a sentence, failed (*Chicago* has *money* in the *river*).

Twelve Year Tests:

1. Resists suggestion, passed.
2. Three words in a sentence, failed.
3. Utters 60 words in three minutes, failed; (27 words. Pauses much, though urged to go fast).
4. Definitions, failed. (Charity? "Don't know." Justice? "Justice of the peace." Goodness? "Gracious.")
5. Rearranges shuffled words in a sentence, failed.

According to the Binet series this boy grades nine years of age, and it might be thought is a fit candidate for the feeble-minded institution. The further disabilities which these tests do not disclose are as follows:

1. He cannot recognize any printed words and not all of the alphabet, though kept in school the regulation time.

2. He can write only his own and his brother's names. Told to write *the cat ran away* wrote *the set,* though he could spell *cat* correctly.

3. He can do simple number combinations such as 5 plus 6, 10 minus 4, by counting his fingers.

4. He knows only that his birthday comes in the summer; said, "My mother told me but I always forget."

5. He has very poor control of associations which do not provide a sense stimulus as is shown in his reactions to the opposite test. Out of 20 stimulus words he reacted correctly to only 6, gave a wrong association for 10, and failed entirely for 4 of the stimulus words.

6. He is very suggestible. In the *Aussage* test accepted 5 out of 7 suggestions.

The positive abilities which this boy possesses and which the Binet tests cannot disclose are:

1. He can do a test involving the planning of a complex set of spatial relationships in a planned and comprehensive way. This ability is disclosed by test IV of the Healy-Fernald series.

2. He has the ability to do in a planned and comprehensive way a test requiring the analysis of the functional relationships of a simple mechanical contrivance, as is disclosed by test V. of the Healy-Fernald series. He also did tests I, II, and III of this series in the manner considered intelligent in the grading adopted in the work of the clinic.

The history of the boy's industrial life correlates with the inference that one might draw from his performance with the mechanical tests. He has been an efficient farm laborer for some months, worked satisfactorily for a creamery for a time loading and unloading cans etc., and as a janitor for a small school building. He is capable of earning his living without direct supervision."

The faults of the Binet-Simon series may then be summed up as follows:

1. The assumption of serial mental development from early childhood to adult age.

2. The omission of tests of socially significant abilities.

3. Failure to distinguish certain innate abilities from a certain expression of them due to age or experience.

4. Is not an accurate measure of mental development of normal children.

5. The assumption that a defective is quantitatively rather than qualitatively different from a normal individual. This point is discussed further on p. 164.

There is a further lack in the series which has been implied in the description of Frank. With the Binet series alone one might have had no hint as to his industrial possibilities. The mechanical tests of the Healy-Fernald type, it is possible, may be made to supply such deficiency. To determine this, studies for the purpose of correlating them with the handwork of the school or other places where such activities can be measured need to be made.

V

DISCUSSION OF BINET-SIMON TABLES

The reactions to the Binet-Simon tests have been summarized in the following seven tables. Each table is arranged with reference to grade, one for each grade. The first column of numbers at the extreme left of each table refers to the individual children. The age of each child is in the second left hand column, and the results of the individual tests are recorded in the following columns. A plus sign indicates success and V failure with the tests according to the Binet-Simon grading, and where modifications from the French are required those adopted by Goddard are followed. Where the author has further modified the standard for grading has been indicated in the text of discussion and in the case of some tests by footnote to the tables.

The tests were given with the Healy-Fernald tests to the group of children described on page 2. These children were considered normal by the teachers who had them in charge. No child known to be defective or seriously backward is admitted to the school. There were some retarded members, the extent of which is shown in table VIII below. The causes assigned by the teachers for retarded cases were, in general, illness, delayed start to school because of the theory of the parent that such a course was best for the child, and the interruption of regular study by travel.

The general technique of procedure was adopted with reference to demands of the Healy-Fernald tests. It is discussed further on page 86.

In the conduct of the two sets of tests the Binet-Simon tests were reserved for the last. By the time they were reached the child had been doing tests for an hour or more. In some cases there was too much restlessness and fatigue to carry the child as far as the majority of his comrades in his grade were able to go

and the tests were then discontinued. This accounts for the unevenness of the right hand side of some of the tables.

Binet-Simon Record of Kindergarten.—Table I shows the record made by the twenty-four kindergarten children. A glance at the table for the tests below nine years shows that the greatest amount of failure occurs with the following tests: the 6-3 test,* six failures to copy the lozenge. When watching these children work at this test one comes to the conclusion that the failure is due to lack of muscular control. The frequently heroic and often unsuccessful attempt to draw the slanting lines of the lozenge is easily apparent. Seven fail at 7-3, describe a picture; 15 at 7-4, give the value of nine cents; 9 at 8-2, to count backward.

The counting backward test was not an utter failure on the part of any child graded V. Those so graded were able to comprehend the problem sufficiently well to make a reasonable attempt at it, and to get more than two-thirds of the required terms correct. The errors were mostly those of omission. They come about in this way; the child has successfully reached perhaps fifteen in his backward progress toward one, and here he pauses to go through the process discussed above by which he determines the next term in the series. He counts up from some term nearer one and having come up to fifteen again, says *thirteen* instead of *fourteen.*

Twenty-four children fail at 8-4, the date; nine at 8-5, to repeat five digits. The 7-4 and 8-4 tests concern themselves with bits of specific instruction not included in the curriculum of the kindergarten.

Of the nine year tests the first four are tests of the results of specific school instruction. The 9-2 test, defines in terms superior to use, may be classed as such because of the usual school exercise of defining words found in the reading and other exercises of the school. The fifth one is a test which involves having formed a generalized rule of action for a given situation. Of the eighteen children who were given the nine year tests, failure was the rule with the first four. Eleven of the eighteen were

* This convention is adopted to indicate test III of the six year group.

TABLE I
Reaction of Kindergarten Children to Binet-Simon Tests
Binet Ages

		4 yr.					5 yr.					6 yr.					7 yr.					8 yr.					9 yr.						Mental
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	age
157	5	+	+	+	+		+	+	+	+	+	√	+	+	√	+	+	+	+	√	+	√	**+**	+	√	√						Kdg	6⅘
158	5	+	+	+	+		+	+	√	√	+	+	+	√	√	+	+	+	+	√	√	+	√	+	√	+						Kdg	6⅖
160	5-3*						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	**+**	+	√	+	√	+	√	√	√	Kdg	7⅘
133	5-6						+	+	+	+	+	+	+	√	+	+	+	+	+	+	+	+	√	+	√	√	√	√	√	√	+	Kdg	7⅗
155	5-8						+	+	+	+	√	+	+	√	+	+	+	√	+	√	+	+	√	+	√	+						Kdg	6⅘
145	5-9						+	+	+	+	+	+	+	√	+	+	+	√	+	+	+	+	+	+	√	√	√	√	√	√	+	Kdg	7⅗
154†	5-9						+	+	+	+	+	+	√	√	+	√	+	+	+	√	+	+	√	+	√	√						Kdg	6⅗
138	5-10						+	+	+	+	+	+	+	+	+	+	√	√	+	+	+	+	+	+	√	+	√	√	√	√	+	Kdg	7⅗
160	5-10						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	√	+	√	√	√	Kdg	7⅘
141	5-11						+	+	+	+	+	+	+	+	+	+	+	√	+	√	+	+	**+**	+	+	+	√	+	√	√	+	Kdg	8
159	5-11						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	**+**	+	√	√						Kdg	7⅖
149	6						+	+	+	+	√	+	+	+	+	√	+	+	+	√	+	+	√	+	√	√						Kdg	6⅘
144	6-2						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	**+**	+	√	+	√	√	+	√	+	Kdg	8
137	6-2						+	+	+	+	+	+	+	+	+	+	+	√	+	√	+	√	√	+	√	√	√	√	√	√	+	Kdg	7
143	6-3						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	√	√	√	√	+	Kdg	7⅘
153	6-4						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	√	+	√	√	+	Kdg	8
135	6-5						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	+	+	√	+	Kdg	8⅖
142	6-6						+	+	+	+	+	+	+	√	+	+	√	√	+	√	+	+	√	+	√	√	√	√	√	√	√	Kdg	6⅗
146	6-6						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	√	+	√	√	√	√	+	Kdg	8
152	6-6						+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	√	+	+	+	√	+	√	√	√	Kdg	7⅘
134	6-10						+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	+	+	√	+	√	√	+	√	+	Kdg	8
151	7						+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	√	+	√	+	√	√	√	√	√	Kdg	7⅖
136	7-4						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+						Kdg	7⅘
147	7-10						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	+	+	√	√	Kdg	8⅕
148	8-1‡						+	+	+	+	+	+	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	√	Kdg	8⅖

* Age is indicated in years and months,—5 years, 3 months.

† Most of √'s were the result of the child's unwillingness to try. Considered by his teacher a problem case. Passed to first grade at end of year.

+ From 10. Was unfamiliar with series to 20.

TABLE II

Reaction of First Grade Children to Binet-Simon Tests

Binet Ages

		5 yr.					6 yr.					7 yr.					8 yr.					9 yr.					10 yr.					12 yr.						Men-tal
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	age
93	6-6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	√	+	√	+	√	√	+	+	+	+	+	√	√	√	1	9
39	6-6	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	√	√	+	+	+	+	√	+	√	√	+	√	+	√	√	1	9
92	6-6	+	+	+	+	+	+	√	+	+	+	+	√	+	+	+	+	+	+	√	+	+	√	+	√	+	+	√	+	+	√	√	√	√	√	√	1	8⅗
96	6-7						+	+	+	+	+	+	√	+	+	+	+	+	+	√	+	√	+	√	√	+	+	√	√	+	+	√	+	√	√	√	1	8⅘
91	7	+	+	+	+	+	+	+	√	+	+	+	+	+	√	+	+	**+**	+	√	+	√	+	+	√	+	+	√	√	√	√†	√	√	+	√	√	1	8⅖
94	7-1						+	+	+	+	+	+	√	+	+	+	+	+	+	√	+	+	+	+	√	+	√	√	+	+	+	+	+	+	√	√	1	9⅗
127	7-1						+	+	+	+	+	√	+	+	√	+	+	+	+	+	√	√	+	+	+	+	+	√	√	+	√							8⅗
86	7-2	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	√	√	√	+	√	√	+	√	√	√	+	+	+	+	+	√	√	1	8⅗
129	7-4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	√	√	+	√						1	9⅕
98	7-5						+	+	+	+	+	+	√	+	+	+	+	√	+	√	+	√	+	+	√	+	+	√	√	+	+	+	√	+	√	√	1	9
88	7-5						+	+	+	+	+	√	√	+	+	+	+	+	+	√	+	+	√	+	√	+	√	√	+	+	+	√	√	√	√	√	1	8⅗
128	7-5						+	+	+	+	+	+	+	√	+	+	+	+	+	+	+	√	+	+	+	+	+	√	+	+	√						1	9⅖
90	7-7						+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	√	√	+	√	+	+	√	+	+	+	√	√	√	√	√	1	8
87	7-10	+	+	+	+	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	+	√	+	+	+	+	+	√	√	√	1	10
97	8											√	+	+	+	+	+	+	+	√	+	√	+	+	√	+	√	√	+	+	+	+	+	+	√	√	1	9⅖
95	8						+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	+	+	√	+	√	+	√	+	+	+	+	√	√	√	1	9⅖
131	8						+	+	+	+	+	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	√	√						1	9
125	8						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	√	+	+	+							9⅖
126	8-2						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+						1	10
89	8-6											+	√	+	+	+	+	+	+	√	+	√	+	+	√	+	+	√	+	+	+	+	+	√	+	√	1	9⅗

+ From 11.

† Succeeded with boy, river, ball.

able to so generalize experience into rules of action as to succeed with the fifth test according to the Binet standard. No child of the eighteen failed to answer at least one of the problems correctly.

Binet-Simon Record of the First Grade.—Passing to the record of the first grade, Table II, we find that here again the tests below ten years which depend upon specific instruction are usually not passed except the 7-4 test. The material of this test is included in the curriculum of this grade. The 9-5 test of experience is universally passed. Perhaps one may venture upon the theory that it is because the children of the first grade have had more and broader social experience than those of the kindergarten. The 10-3, 10-4, and 10-5 tests, are passed by approximately two thirds of the first grade children. There is almost entire failure with the 10-2, test of visual memory, and more than fifty per cent of failure with the discrimination of weight.

Binet-Simon Record of the Second Grade.—With the second grade, Table III, the reaction to the 10-3, 10-4, and 10-5 tests remains the same as for the first grade, as do practically the weight discrimination and visual memory tests. The 12-4 test, definition of abstract terms, is generally missed, and the 12-5, test of rearrangement of words to make a sentence. This test was graded *V* in accordance with Binet's standard of the time factor, failure in one minute. Many of the children were given more time and several trials and finally accomplished the result. It is characteristic of the child who fails according to the Binet standard that he is unable to see the sentence entirely. He puts a few words together in the right relation and a few others in their right relation, and then he finally criticises the whole product. In no case was a child who failed to do the test satisfied with his result.

This is in striking contrast with the behavior of the defective child. The latter does not criticize his failures. If he tries to perform the test he is usually satisfied with the result.

TABLE III
Reaction of Second Grade Children to Binet-Simon Tests
Binet Ages

		6 yr.					7 yr.					8 yr.					9 yr.					10 yr.					12 yr.						Men-tal
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	Age
32	7-6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	√	√	+	√	√	+	+	+	√	+	+	+	√	2	9⅖
36	7-7						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	√	+	+	√	+	√	+	√	√	2	9⅗
29	7-8						+	√	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	+	+	+	√	+	+	+	√	2	10⅕
37	7-8						+	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	2	10⅘
38	7-8						+	+	+	+	+	+	+	+	√	√	+	√	+	+	+	+	√	√	+	√	+	√	+	√	√	2	9⅕
27	7-9						+	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	+	+	√	√	2	10⅖
33	7-9						+	+	+	+	+	+	+	+	+	+	√	+	+	√	+	√	√	√	+	√	+	√	+	√	√	2	9⅕
30	7-10						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	+	+	+	√	√	+	√	√	2	9⅘
34	7-10						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	√	2	10⅖
31	7-11	√	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	√	+	+	+	+	+	+	+	+	√	+	+	√	√	2	10'
35	8						+	+	+	+	+	+	+	+	+	+	√	+	+	√	+	√	√	+	+	√	+	√	+	√	√	2	9⅖
28	8-2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	√	+	+	+	+	+	√	√	√	2	10
23	8-7	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	√	+	+	+	+	+	+	+	√	√	2	10⅕
25	8-8						+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	√	√	+	+	+	+	+	+	+	√	2	10⅕
24	8-9						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	√	+	+	+	+	+	+	+	+	+	2	10⅘
26	8-10						+	+	+	+	+	+	+	√	+	+	+	+	+	+	+	+	√	+	+	+	+	+	√	√	√	2	10⅕
22	9-3											+	√	+	+	+	+	√	+	+	+	√	√	+	+	+	+	+	+	√	√	2	10⅘

Binet-Simon Record of Third Grade.—The children of the third grade, Table IV, continue in large numbers to fail in the 10-1, 10-2, 12-4, and 12-5 tests. It is interesting to note that the reaction to the 12-1 test of suggestion has changed in character. The second grade child made no error in his judgment, but the third grade child, perhaps in his desire to exercise great care, fell into the error of judgment which has been discussed above.

TABLE IV

Reaction of Third Grade Children to Binet-Simon Tests
Binet Ages

		8 yr.					9 yr.					10 yr.					12 yr.						Mental
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	Age
20	8	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	V	V	V	3	10 2/5
21	8-2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V	3	10 4/5
6	8-8	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	+	+	+	V	V	3	10 1/5
12	8-9	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	V	3	10 3/5
10	8-10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V	+	3	10 4/5
2	9	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	+	+	V	+	V	3	10 1/5
3*	9	+	+	+	+	+	+	+	+	+	V	+	V	+	+	+†	+	V	V	V	V	3	9 4/5
13	9-2	+	+	+	+	+	+	+	+	V	+	+	V	+	+	+	+	+	V	+	V	3	10 1/5
5	9-2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	V	V	V	3	10 2/5
7	9-2	+	+	+	+	+	V	+	+	+	+	V	V	+	+	+	**+**	+	+	+	V	3	10 1/5
8	9-2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V	V	3	10 3/5
1	9-3	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	**+**	+	V	+	V	3	10 1/5
11	9-4	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	**+**	+	+	+	V	3	10 3/5
4	9-4	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	**+**	+	+	V	V	3	10 2/5
9	9-4	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	**+**	+	+	+	V	3	10 3/5
17	9-9	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	**+**	+	+	V	V	3	10 2/5
16	9-9	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	**+**	+	+	+	V	3	10 3/5
18	9-11	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	+	+	V	3	10 4/5
14	10-2	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	**+**	+	V	V	V	3	10 1/5
15	10-4	+	V	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	+	+	+	3	12-11
19	10-4	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	V	V	V	3	10 1/5

+ Wrong judgment.
† V with Chicago, money, river, with boy, river, ball.
* Considered a pathologically timid case, but not lacking in ability. V's apparently due to fear of expressing a wrong judgment.

Binet-Simon Record of Fourth Grade.—The fourth grade, Table V, shows much the same type of reactions as the third grade.

TABLE V

Reaction of Fourth Grade Children to Binet-Simon Tests

Binet Ages

		8 yr.					9 yr.					10 yr.					12 yr.						Mental Age
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	
41	9	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	V	+	+	V	+	4	10⅖
40	9-5	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	4	10⅘
47	9-9	+	+	+	+	+	+	+	+	V	+	V	+	+	+	+	+	+	+	+	V	4	10⅖
53	9-9	+	+	+	+	+	+	V	+	+	+	V	+	+	+	+	**+**	+	+	V	V	4	10⅕
56	9-9	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	V	+	+	+	V	4	10⅕
51	9-10	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	+	4	10⅘
48	9-10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	+	+	V	4	10⅘
45	10	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	**+**	+	+	+	V	4	10⅖
50	10-1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V	+	+	V	4	10⅗
55	10-2	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	V	V	4	10⅖
52	10-2	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	+	+	+	+	V	4	10⅖
46	10-4	+	+	+	+	+	V	+	+	+	+	V	V	+	+	+	**+**	+	+	+	V	4	10⅕
49	10-4	+	+	+	+	+	+	+	+	+	+	V	V	+	+	+	V	+	+	+	V	4	10⅕
54	10-5	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	+	4	10⅘
57	10-5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	+	+	V	4	10⅘
44	10-5	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	+	+	+	V	4	10⅗
61	10-8	+	+	+	+	+	V	+	+	+	+	V	+	+	+	+	+	+	+	V	V	4	10⅕
59	10-9	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	**+**	+	+	+	V	4	10⅗
60	10-9	+	+	+	+	+	+	+	+	+	+	+	V	+	+	+	**+**	+	+	+	V	4	10⅗
58	11-2	+	+	+	+	+	+	+	+	+	+	V	+	+	+	+	**+**	+	+	V	V	4	10⅖
63	11-6	+	+	+	+	+	V	+	+	+	+	V	+	+	+	+	**+**	+	+	V	V	4	10⅕
62†	12-2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**+**	+	+	+	+	4	12

+ Wrong judgment, opposite to suggestion judgment.

† Add to No. 62 one column as follows: 15 yr. V + V V +

Binet-Simon Record of Fifth Grade.—The fifth grade, Table VI, shows itself capable of doing the 12-5 test and fails in large numbers in the 10-1 and 10-2 tests. The 15-3, test of memory of sentence of twenty-six syllables, and the 15-4, interpretation of a picture, were generally failure.

TABLE VI

Reaction of Fifth Grade Children to Binet-Simon Tests

Binet Ages

No.	Age	9 yr. 1 2 3 4 5	10 yr. 1 2 3 4 5	12 yr. 1 2 3 4 5	15 yr. 1 2 3 4 5†	Grade	Mental age	
66	10-3	+ + + + +	V + + + +	**+** + + + +	+ + + V B	5	12 3/5 or 11 1/5	
65	10-3	+ + + + +	+ + + + +	+ + + + +	+ + + V +	5	12 4/5	
64	10-5	+ + + + +	+ V + + +	**+** + + + +	+ + V V V	5	12 2/5	11
67	10-6	+ + + + +	V V + + +	**+** + + + +	V V V V V	5	12	10 2/5
69	10-6	+ + + + +	V V + + +	+ + + + +	+ + V + +	5	12 4/5	11 3/5
72	11	+ + + + +	V + + + +	**+** + + + +	+ + V V B	5	12 2/5	11
71	11-2	+ + + + +	+ + + + +	**+** + + + V	+ + V V +	5	12 2/5	11 1/5
73	11-2	+ + + + +	+ V + + +	**+** + + + +	V + V V +	5	12 2/5	11
68	11-5	+ + + V +	+ V + + +	**+** + + + V	V + V + A	5	10 4/5	10 3/5
70	11-5	+ + + + +	+ V + + +	**+** + + + +	+ + V V +	5	12 3/5	11 1/5
74	11-6	+ + + + +	V + + + +	**+** + + + +	V + V V +	5	12 2/5	11
78	11-6	+ + + + +	+ V + + +	**+** + + + +	+ + V V A	5	12 2/5	11
79	11-8	+ + + + +	+ V + + +	**+** + + + +	+ + V V A	5	12 2/5	11
77	12	+ + + + +	+ + + + +	**+** + + + V	+ + V + +	5	12 3/5	11 3/5
76	12-1	+ + + + +	+ V + + +	+ + + + +	+ + V V +	5	12 3/5	11 1/5
75	12-2	+ + + + +	V V + + +	**+** + + + +	V + V V +	5	12 2/5	10 4/5
83	12-6	+ + + + +	+ V + + +	**+** + + + +	V V V V B	5	12	10 3/5
80	12-7	+ + + + +	V V + + +	**+** + V V +	+ V V V +	5	10 3/5	10 2/5
82	12-7	+ + + + +	+ + + + +	**+** + + + V	V + V V +	5	12 1/5	11 1/5
84	12-11	+ + + + +	V V + + +			5	9 3/5	
81	12-11	+ + + + +	+ V + + +	**+** + + + +	V + V V +	5	12 2/5	11
85	13-8	+ + + + +	+ V + + +	**+** + + + +	+ + V V +	5	12 3/5	11 1/5

+ Wrong judgment.

† A and B indicate problems 1 and 2, respectively, of the test passed.

Binet-Simon Record of Sixth Grade.—The reactions of the sixth grade, Table VII, were much the same as those of the fifth. The adult tests were given to the sixth grade as a class, the results being written by the children and handed in. Of the adult tests, number 2, *rearranges a triangle,* and 3, *give differences in meanings of abstract terms,* were answered by two thirds of the class. The matter of test four is not a part of the organized civics work of this grade, and the information in sufficiently organized form to permit of an attempt to answer the question must have been obtained through general reading by those who succeeded.

TABLE VII

Reaction of Sixth Grade Children to Binet-Simon Tests

Binet Ages

		12 yr.					15 yr.					Adult						
No.	Age	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Grade	Mental age
115	12	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	6	A
116	12	+	+	+	+	V	+	+	+	+	+	V	+	+	+	+	6	15⅘
124	12	+	+	+	+	V	V	+	V	V	+	+	V	V	+	+	6	12
105	12-1	+	+	+	+	+	+	+	V	+	V	V	+	+	V	+	6	12⅕
109	12-1	+	+	+	+	+	+	+	+	+	+	+	+	+	V	V	6	15⅗
104	12-1	+	+	+	+	+	+	+	V	+	+	+	V	+	+	+	6	15⅗
123	12-1	+	+	+	+	+	+	+	V	V	+	V	+	+	V	+	6	15⅕
111	12-2	+	+	+	+	+	+	V	V	V	+	V	+	V	V	+	6	12⅘
100	12-2	+	+	+	+	+	+	+	V	+	V	+	+	+	+	V	6	15⅖
114	12-3	+	+	+	+	+	+	+	V	+	+	+	+	V	V	V	6	15⅕
102	12-6	+	+	+	+	V	+	+	V	+	V	V	+	+	V	V	6	12⅘
106	12-6	+	+	+	+	+	+	+	V	+	+	V	V	+	V	+	6	15⅕
119	12-8	+	+	+	+	+	V	+	V	+	+	V	V	+	V	V	6	12⅘
118	12-8	+	+	+	+	+	V	+	+	+	+	V	+	+	+	V	6	15⅖
113	12-8	+	+	+	+	+	+	V	V	+	+	+	+	+	+	+	6	A or 15⅗
108	12-9	+	+	V	+	+	+	+	V	+	+	V	V	V	V	V	6	10 or 11
103	12-9	+	+	+	+	+	+	+	V	+	V	V	V	V	V	V	6	12⅗
120	12-11	+	+	+	+	+	+	V	V	+	+	V	+	+	V	+	6	15⅕
99	13	+	+	+	+	+	+	V	V	V	A	V	+	V	V	V	6	12⅖
122	13	+	+	+	+	V	+	V	V	V	+	V	+	+	V	+	6	12⅘
117	13-4	+	+	+	+	+	V	V	V	V	+	V	+	+	+	V	6	12⅘
110	13-5	+	+	+	+	+	+	+	V	+	V	+	+	+	+	V	6	15⅖
107	14-2	+	+	+	+	V	V	V	V	V	V	V	+	V	V	V	6	12

The final column of each table shows the mental age attained by each individual. Where the ages of ten and twelve and fifteen overlap there is some ambiguity as to the grading for mental age. Should the children who fail in some of the ten year tests but make the additional five in the twelve and fifteen sets be graded eleven years or twelve years mentally? The type of performance with the 12-1 test also complicates the grading. Where there may be an alternative grade the fact has been indicated in an additional column.

The results are arranged in table VIII which shows the relation of chronological age to mental age. In this table are indicated the alternative gradings and the resulting alternative percentages. The 150 children grade 14 per cent (or 20) retarded, 26 per cent (or 24) normal, and 55 per cent (or 54) advanced.

Table VIII

Chronological age	Mental Age 6	7	8	9	10	11	12	15	A.	Number	Retarded Number	Retarded %	Normal Number	Normal %	Advanced Number	Advanced %
5 to 5-6	2	1								3	0	0	0	0	3	100
5-6 to 6-6	3	7	4							14	0	0	3	21	11	78
6-6 to 7-6	1	3	8	6						18	1	5	3	16	14	77
7-6 to 8-6		1	3	11	10					25	1	4	3	12	21	84
8-6 to 9-6				3	18					21	0	0	3	14	18	85
9-6 to 10-6					19	[3]	4 or 1			23	0	0	19	82	4	17
10-6 to 11-6					5 or 7	[4]	6 or 0			11	5 or 7	45 63	0 or 4	0 36	6 or 0	54 0
11-6 to 12-6					0 or 1	[5]	9 or 3	6	1	16	0 or 6	0 38	9 or 3	56 18	7	43
12-6 to 13-6				1	2 or 3	[3]	9 or 5	4 or 5	1 or 0	17	12	70	0	0	5	29
13-6 to 14-6							2			2	2	100				
Total										150	21 or 30	14 or 20	40 or 37	26 24	88 or 81	58 54

Showing the relation of chronological to mental age of 150 normal children.

With these results we may compare those of table IX, which shows the relation of grade to chronological age. The numbers in heavy type mark those of normal age for the grade. Since the data was obtained at the end of the school year the normal age for the kindergarten is that of the beginning first grade, for the first grade that of the beginning second grade, etc.—that is, the kindergarten children were ready for the first grade and became first grade children at the beginning of the next year. The table shows that 38 per cent are retarded, 56 per cent normal and 4 per cent advanced with respect to their school work as compared with the 14 per cent, 26 per cent and 58 per cent respectively with respect to Binet-Simon mental age.

TABLE IX
Age Grade Correlation

Grade	Chronological Age										Retarded		Normal		Advanced	
	5 to 6-6	6-6 to 7-6	7-6 to 8-6	8-6 to 9-6	9-6 to 10-6	10-6 to 11-6	11-6 to 12-6	12-6 to 13-6	13-6 to 14-6	Number	Number	%	Number	%	Number	%
Kdg.	**17**	6	2							25	8	32	17	68	0	0
I		**12**	7	1						20	8	40	12	60	0	0
II			**12**	5						17	5	29	12	70	0	0
III			2	**13**	6					21	6	28	13	61	2	9
IV				2	**14**	4	2			22	6	27	14	63	2	9
V					3	**7**	6	5	1	22	12	54	7	31	3	14
VI							10	12	1	23	13	56	10	43	0	0
Total										150	58	38	85	56	7	4

Showing relation of grade to chronological age of 150 normal children.

Table X shows the relation of school grade to the mental age grading of the Binet series. If school grade age and Binet age correspond the normal Binet age for the Kindergarten would be six years, for the first grade seven years, etc. The normal mental age for the grade is indicated by the heavy type. The number retarded according to the Binet age with reference to the normal grade age is 2 per cent (or 4); normal, 25 per cent (or 35); advanced 72 per cent (or 60).

The results of the three preceding tables arrange themselves as follows:

Retarded	Normal	Advanced	
14 (or 20) %	26 (or 24) %	58 (or 54) %	By Binet Age to Chronological Age.
38	36	4	By School Grade to Chronological Age.
2 (or 4)	25 (or 35)	72 (or 60)	By Binet Age to School Grade Age.

These figures show the wide variance in the various gradings. Where the school grading shows 4 per cent advanced over the normal for the chronological age, the Binet grading shows 58 per cent over the chronological age and 72 per cent over the age normal to the school grade.

TABLE X

Grade	Mental Age 6	7	8	9	10	11	12	15	A.	Number	Retarded Number	Retarded %	Normal Number	Normal %	Advanced Number	Advanced %
Kdg.	6	11	8							25	0	0	6	24	19	76
I		0	7	11	2					20	0	0	0	0	20	100
II			0	7	10					17	0	0	0	0	17	100
III				1	19	[1]	1 or 0			21	0	0	1	4	20	95
IV					21		1			22	0	0	21	95	1	4
V				1	2 or 5	[15]	19 or 1			22	3 or 6	13 or 26	0 or 15	0 or 68	19 or 1	86 or 4
VI					1 or 0	[1]	10	10 or 11	2 or 1	23	1	4	10	43	12	52
Total										150	4 or 7	2 or 4	38 or 53	25 or 35	108 or 90	72 or 60

Showing relation of normal grade age to Binet mental age of 150 normal children.

Table X when analyzed further shows that below the fourth grade the Binet tests are not suited to children with the educational experiences of those grades, since from 76 per cent to 100 per cent are advanced by the Binet tests over the age normal to the school grade. At the fourth grade the age normal to school grade and the Binet age correspond very closely. At the fifth grade the Binet age is advanced or rather close to the normal according to the convention chosen for the Binet grading. At the sixth grade it is rather evenly divided between advanced and normal.

VI

STANDARDIZATION AND DISCUSSION OF THE HEALY-FERNALD TESTS

Origin of the Healy-Fernald tests.—The Healy-Fernald set of tests was worked out for two purposes. The first was for the purpose of supplementing the Binet-Simon series. It was discovered in the work of the clinic that the Binet-Simon series failed to explore with sufficient thoroughness the mentality of the child. The objections to the Binet-Simon series have been discussed above.

The second reason for the preparation of the new tests arose from the language difficulty which confronted the workers of the clinic. Many children who come to the clinic are of foreign parentage or from homes where a foreign language is spoken. In many cases they come from parochial schools where little English is taught or used. In other cases, especially those of rather young children, the reactions to the Binet-Simon tests were of doubtful significance, because the tester could not be sure that the language in which these tests were given was completely understood by the child. The difficulty of using the English language with a child from an alien speaking home can be appreciated only by one who has mingled with these children informally on their own ground. The child confronts a situation in which he has not only two languages with which to deal, but rather three. There is the foreign language in the home, the patois which he gets on the street, and the classical language of the cultured person with whom he comes in contact at school or other cultural institutions. The street patois is surely not an unimportant factor in causing mental confusion in the mind of the child. In the realm of patois a man is never a man, he is a *guy;* a boy is never a boy, he is a *kid;* a foolish person is never such, he is a *mut;* one never stops doing something, or is commanded to leave off doing something, he

must always *cheese* it; and so on interminably. The confusion can well be imagined in the mind of the child who, at home, is told in a foreign language by his mother to leave off doing something; who by his older brothers or street companions is commanded to *cheese* it; and who by his teacher or other cultured person with whom he comes in contact, is in more or less classical terms requested to stop his misconduct. If the child has never attended a public school, but only a parochial school in which English is very little taught, the difficulty of examination with such a series of tests as the Binet-Simon, which makes use of language almost wholly, can well be imagined. For these reasons, tests which show the functioning of intelligence without the necessity of accuracy in the use of language were originated by the workers and friends of the Psychopathic clinic.

Evaluation of Results.—In the attempt to express the difference between the defective and the normal human intellect one is confronted by two possibilities. The first is, that there exists a distinguishable qualitative difference. This idea was most vividly expressed by Tregold when he said that there exists between the highest ament and the lowest normal individual an impassable gulf. The qualitative factor of difference has been discussed with reference to the application of the Binet-Simon tests to the task of distinguishing between the normal and the defective. The second possibility is that the difference is only a quantitative one. It is to the effect that there exists a normal curve of distribution of mental abilities corresponding to the theoretically normal curve to be obtained from a large mass of fine measurements. Notwithstanding the theory of qualitative discrimination underlying its origin the attempt has been made by Goddard, Kuhlman, Chotzen and others to fit the Binet-Simon series into this conception. Their theory of the difference between the normal and the defective is that the latter takes more time chronologically to reach a certain point of development than does the former. Clinical experience in getting developmental histories of defectives goes to show that in many phases of development that is the case. Defective chil-

dren learn to walk and talk later than normal children. In matters of formal education they acquire more slowly. In the clinic which has for its task the classification of children for educational, penal or other practical social purposes this type of data is inadequate to fulfill the demands of the situation. Developmental history can not always be obtained with accuracy; there are many causes of retardation of the developmental phases of early life the effects of which do not persist to a later period; progress in formal education and acquiring of information may be interfered with by any one or more of several physical and social factors.

This use of the time factor is only another application of the quantitative idea of difference discussed in the first chapter. The use of the time factor whether in the sense of marking off developmental ranges of difference, or whether applied in the rigorous laboratory method to specific tests can make the point of distinction between the normal and the defective only an arbitrary matter. With the curve of normal distribution of quantitatively measurable phases of mental processes before us who is to decide this determining point and upon what basis?

In order to give a further meaning and value to the quantitative data obtainable in a clinical examination the writer proposes certain qualitative classifications in the discussion to follow.

The quantitative data used to determine the qualitative classifications to be described below are, for the most part, number and types of errors. The classifications are made upon such considerations as the relation of error in individual cases to the number of errors possible to the test to be evaluated, other conditions peculiar to the test itself, and the object of the test from the standpoint of the child.

Some of the reasons for the exclusion of time measure in evaluation of results were discussed above. They are inherent in the demands of the clinical situation. The motive to make a good time record is unsuited to the practical demands of the clinic, because it is the desire there to test for the most part such processes as require attentional control in a new situation.

For some tests such as tapping tests and the Thorndike *a* test, the time measure is an important factor. In such tests there is no new discrimination in the perceptual or other mental processes to be made. If other things, such as the avoidance of error or the making of a plan for a bit of work, are of most importance, time can not except within large limits be taken into consideration. In the writer's proposed classifications the only use of the time factor is to mark the point where the child's reaction to the test may be classed as failure.

A further reason for eliminating time measure from the evaluation of results is that much time may be wasted by the child who is working from the play motive. His attention may be often diverted from consideration of the end of the test. If he stops to remark that it is a pretty puzzle, or to ask who made it, the amount of time so wasted will depend somewhat upon the tact of the examiner in again directing his attention to the work in hand. This, then, leads to the further consideration that one does not know whether one unit of time has been of the same value as any other unit in the performance of the test. If the child takes some time apparently examining the test before him before beginning, or stops to do so at any time during the performance of it, one does not know what is taking place in his mind. One does not know whether he is examining it with reference to the requirements of the test; or is occupying his attention with something quite apart from the object of the test such as the colors or the grain of the wood when doing puzzle tests; or is only staring and not thinking or planning. In an examination one is sometimes at a loss as to how to direct the attention of the child because what he is really doing can be often only a matter of conjecture.

It has been shown in the first chapter that laboratory tests suitable to such fine discriminations of measurement as is demanded in rigorous laboratory method correlate more or less doubtfully with general intelligence, the matter to be determined, or measured. The reason for this is that there exists no measure of general intelligence which permits of such fine discriminations as are used in laboratory tests. An analogous

process in the realm of physics would be the attempt to find a proportion between an object measured with a micrometer and another measured with a yard stick. The object of the clinic for the present should be to find such tests as will present suitable situations in which the general intelligence may function, rather than to find a correlate or measure in simple mental processes. The tests should be of various grades of complexity, but analyzable with reference to such standards as we possess for judging human social conduct. It is with the belief that they correspond to mental processes concerned in the social adjustment of the individual, and in the relation of the individual to social progress, that the writer proposes the following qualitative classifications of reaction to the tests under discussion.

The three classifications chosen are termed, *planned* reaction, *trial and error* reaction and *chance* reaction. In the first type the subject applies his previous experiences of the kind presented to him by the test to the solution of the specific problem before him, with a minimum of error. In the second type the situation is approached as though entirely new, in which there is little conscious application of previous experience to the solution of the problem presented, but in which the experiences presented by the present problem become the basis for attack upon a new problem of similar type. In the third type of reaction every new problem is wholly new, and the experiences of early attempts with it do not become a basis for conscious modification of reaction in further work with it.

The animal or low type of human intellect arrives at new attainments such as the opening of a lock, through a chance coördination gained after much trial and error. Every new lock must be an entirely new problem. Such an intelligence does not generalize upon past experiences in such way as to bring about an adaptation of the old response to the changed conditions of the old type of problem.

In the following tables may be noticed certain time correlations with grade and in one case, Table XXI, with method of procedure or type of reaction. Since, however, the time de-

creases with the higher grades for both types of reaction, the decrease has no relation to the mental process. It probably indicates increase of motor ability with the higher grades.

General Methods of Procedure in Giving Tests.—The private school children to whom the tests were given were told by the principal that we had some games with which they might play, coming one at a time, and that we wanted to see how well they liked them. They were told not to tell their mates about the games after having played with them, for it would spoil the fun of those who were still to see them. This way of putting the matter was very effective, for the children who had not yet had the tests would not permit those who had to discuss them. An effort was made to send each child back to his school room with the feeling that he had had a very good time. The other children then came with only pleasant anticipations. The children were given the tests singly in a quiet room with which they were familiar. The word quiet is not intended to convey the idea that it was noiseless. As a matter of fact it was on a street car line and many other noises such as the closing of doors, etc., reached it. The noises were such, however, as the children were accustomed to hearing and did not distract attention.

The older children who were not satisfied with the reason for giving the tests were told that we wanted to see how much better older children could play the games than younger ones. Very few of the children asked for a reason further than the one given them by the principal, that the games were intended for their own amusement. In the clinic it has been found that this reason generally suffices. In case the real reason is demanded it is generally best to give one that assures the child of the examiner's personal friendship toward him. One to the effect that we want to see how well he can do these things so that we may know what kind of work to get for him or how to help him out of his trouble, if coupled with the assurance all along that he is doing well, is always satisfactory.

Test I. Introductory Picture Form Board.—This test, with the exception of the sixth grade, was always given first. Its

FIG. I

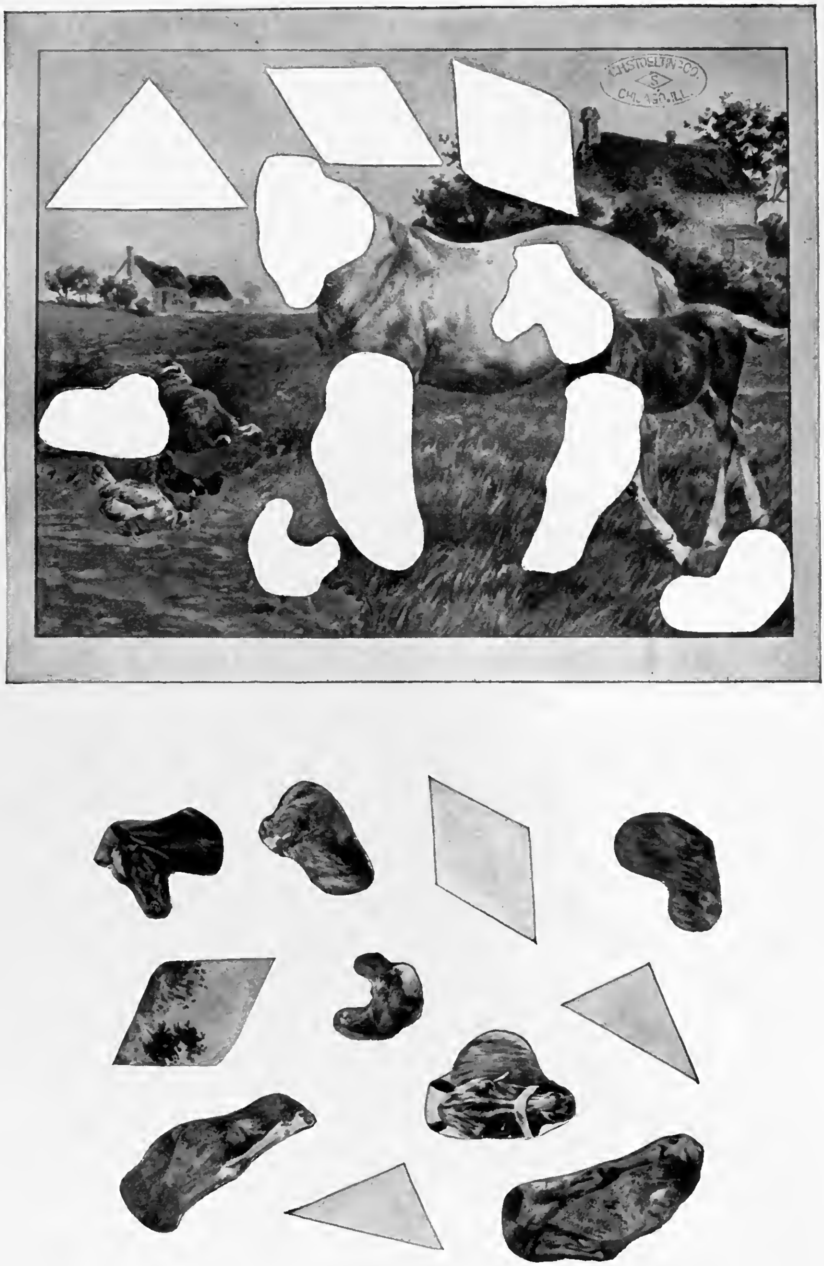


PLATE I

A PICTURE FORM-BOARD—OUR TEST I

An example of a test in which form and color perceptions, some apperceptions, and methods of trial and success are brought out.

From INDIVIDUAL DELINQUENTS—HEALY
Courtesy Little, Brown & Co.

bright colors and the animal pictures immediately excite interest. Its simplicity disarms suspicion that anything unusual or difficult will be required. The pleasure of constructing the puzzle leaves the child in a very pleasant and anticipatory frame of mind for further tests. By giving tests of this character first the child's friendliness for, and confidence in the examiner grows to such an extent that he is willing to undertake tests of a less immediately interesting character.

The design shows a certain number of pieces cut out on the natural lines of some of the objects in the picture, together with four other pieces, one of which is irregular in shape, and three of which are cut on geometrical lines. Two of these last somewhat resemble each other, but are not interchangeable. The third is an isosceles triangle divided into two right angle triangles. The purpose of this was to provide for a simple trial and error procedure, if the make-up of the parent triangle was not at once recognized—as it usually is not.

The puzzle is put before the child, the pieces scattered at random on the table, with the remark that here is a pretty puzzle which one would like to see how well he can do. With the exception of the divided triangle this test presents a one to one relationship between the openings and the pieces to be placed, that is there is one opening for each piece. The usual procedure is to leave the divided triangle until the last, since there is no place for either piece alone. The high grade child above five years of age makes few errors or none at all in placing pieces other than those of the divided triangle. That is, he does not attempt to put a piece where it does not belong, the head where the legs ought to be, etc. The child of low grade intelligence places the pieces by trial and error, trying each piece in each opening until he finds the one in which it fits. The still lower grade of intelligence persistently tries to fit a piece into an opening and finally fails of accomplishing the test because his lack of recognition of failure has prevented his giving up a misfit attempt in favor of another opening for the piece he is trying. The divided triangle, because of the

difference between the numerical relation of the opening and the pieces, really constitutes a test within itself. It may be placed without any trial and error, in which case the subject immediately perceives the relation between the opening and the pieces. It may be placed by trial and error in which the pieces are turned around and around until the right position is hit upon. The most common error of the child in this repeated trial and error is to turn the piece through an arc of 180° or more instead of through 90° which would accomplish the task. Because of the diversity between the body of the puzzle and the triangular portion these two parts are tabulated as two distinct tests. Table XI presents the data obtained from the body of the puzzle.

TABLE XI

Introductory Puzzle. Test 1. (Body of Puzzle)

			Errors							
			0 errors		1 & 2 errors		3 to 5 errors		6 or more errors	
Grade	Number	Average Time	Number	%	Number	%	Number	%	Number	%
Kdg.	27	1′-41″	9	33	7	25	8	29	3	11
I	21	1′-21″	16	76	3	14	2	9	0	0
II	17	1′-16″	9	52	5	29	3	17	0	0
III	21	1′- 4″	10	47	7	33	4	19	0	0
IV	24	1′- 3″	13	54	11	45	0	0	0	0
V	22	1′-10″	12	54	9	40	1	4	0	0

The table shows the average time of performance of the children of the different grades, and the number and per cent of errors which are indicated in the fourth and succeeding columns to the left. An error is any wrong attempt to place a piece. It is counted an error to take any piece and attempt to place it in an opening other than the one in which it fits; if the piece is turned about and placed in another wrong opening another error is scored; if the attempt is made to place a piece in its own opening upside down an error is scored; if a piece is discarded and later tried again in the same wrong opening an additional error is scored for the second and each succeeding wrong attempt. The table shows that the trial and error is small after the kindergarten, when 80 per cent or more of

each grade perform the puzzle with less than three errors; 89 per cent of the kindergarten children make less than six errors. The most common errors are the attempts to interchange the two heads, the two legs, and the diamond and modified diamond. The errors of normal children are attempts to interchange these roughly paired pieces. Defective children will attempt such errors as placing a head where a leg should be, etc.

Table XII presents the data obtained from the triangular portion of the test. The data are arranged to show the average time required to arrange the two pieces in the opening, and the type of mental process which the child employed in accomplishing the task. The data have been arranged to show two types or methods of work, the *trial and error* method and the *planned* method. A child was recorded in the trial and error column if he tried each piece in more than two positions before finding the right one, and in the planned column if he tried one or both pieces in less than two positions before finding the right one. A more careful grading of the trial and error method is not practicable because the pieces are turned quickly and often held covered up.

TABLE XII

Introductory Puzzle, Test I (Triangle)

Grade	Number	Average time	Method: Failure		Method: Trial & error		Method: Planned	
			Number	%	Number	%	Number	%
Kdg	27	1′-36″	4	14	23	100	0	0
I	21	1′-28″	1	4	15	76	5	23
II	17	1′-25″	1	5	12	70	5	29
III	21	1′-25″	0	0	12	57	9	42
IV	24	54″	0	0	21	88	3	11
V	22	33″	0	0	13	59	9	40

The percentage of trial and error of the above table is that of the sum of the trial and error and the failure records. The object is to find the percentage of children who do not do the test by a method superior to that of trial and error. It is probable that those marked failure, if permitted to work indefinitely, would accomplish the task. The table shows that

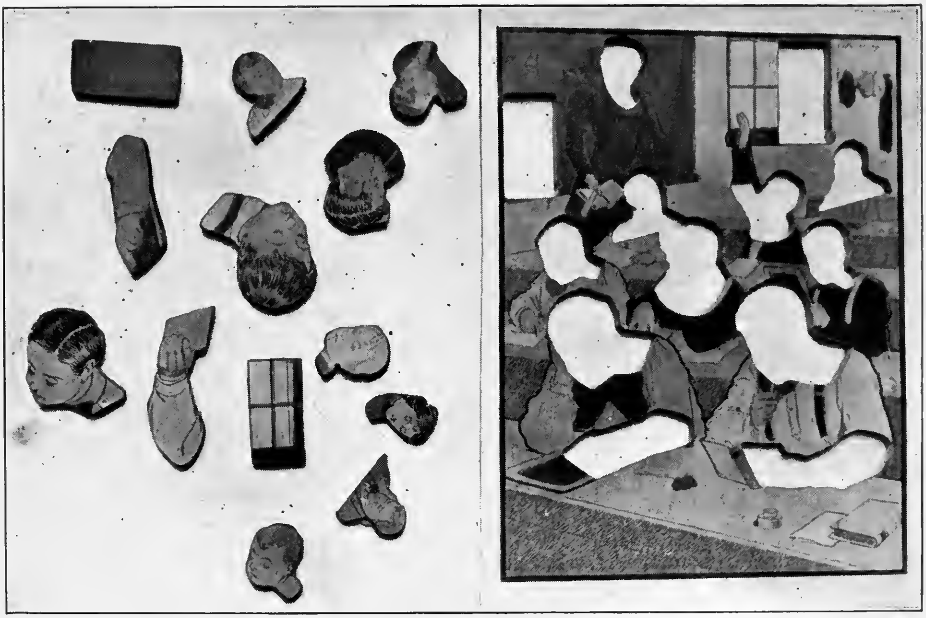
from 60 per cent to 100 per cent of the children between the kindergarten and the fifth grade have not had sufficient experience with such geometrical problems to enable them to do this one without trial and error. Since, then, the problem cannot be used as a test of a child's ability to perceive the spatial relationship involved without error, it may be used as a test of his ability to learn by experience with it. Twenty-six of the kindergarten children were asked to do the triangle a second time. Those who had failed in five minutes were shown how to do it. Of these twenty-six children, twenty did it a second time without error, requiring, with one exception, not more than twenty seconds; three children did it a second time with repeated trial and error, but the third time without error; and three did it a second time with error but no repeated error, that is no wrong position for each piece was tried more than once. These results may be compared with those obtained from delinquent children seen at the Juvenile Court Clinic mentioned above.

Of twenty-six children between 7-6 and 8-6 years of age seen at the clinic, five because of their reactions to this and other tests, were graded feeble-minded. Of these five cases, three failed to complete the body of the puzzle because of lack of recognition of failure in attempting to place the pieces; two others failed to complete the triangle. Among those graded normal there were no failures of either part of the puzzle; four of the normal children made six or more errors in doing the body of the puzzle, four did the triangle by trial and error. Of twenty-two children between the ages of 8-6 and 9-6 years, three were graded feeble-minded. Two of these children accomplished the whole puzzle, with more than six errors for the body and the triangle by trial and error; the third failed on the triangle. Of the children graded normal, one failed to accomplish the puzzle, one made six errors, and two did the triangle by trial and error, and one failed to do the triangle.*

* In the process of evaluating a child's mental condition, in general, failure with one test which the child's age might lead one to expect him to accomplish is disregarded if he has uniformly accomplished more complex tests. One must take into consideration the fact that clinical conditions can not

90a

FIG. 2



Above this age failure in one or both parts of this test always accompanies the condition of feeble-mindedness, but not all feeble-minded persons above this age fail in the test.

Test II. Special Picture Puzzle. This test was given second in order to the first four grades. The twelve pieces of the puzzle are so cut as to form five rather closely resembling pairs and two unpaired pieces. Four of the pairs differ in shape and cannot be interchangeably placed. The quadrilateral pieces can be interchanged.

Except for the two unpaired pieces the differences of form are not sufficient to serve as a guide in placing the pieces. The placing must be accomplished by the matching of the lines and colors preserved on the piece with those of the surrounding picture.

In giving the test the form is placed before the child with the pieces scattered at random. He is told that "the game" with this puzzle is to look so carefully at each piece before attempting to place it that he will not try to put any piece where it does not belong; that is, that he should not try to give anyone the wrong head, but give to each one just what belongs to him at the very first trial. If the child makes an error in attempting the first piece the warning is again repeated with the remark that he has just made a mistake and should look carefully and not do it again. With young children the author has tried to excite greater interest in doing the puzzle carefully by saying that to try to give any boy the wrong head hurts him very much and care should be taken not to do that. This extra appeal to the imagination, however, while amusing the child, does not seem to stimulate him to greater care in placing the pieces. Apparently the type of motive for doing the puzzle, whether the humanitarian one just referred to or the play motive or the desire to please the examiner who has asked him to do it, has no effect upon calling into greater activity his ability to do it.

In the performance of this test account is kept of time and

always be kept uniform with reference to the child's motives, and that the child's reactions are not always uniform with reference to his general mental level.

errors. Attempts to place a piece in the wrong opening, to place one upsidedown in its own or a wrong opening, attempts to interchange the quadrilateral pieces, are counted as errors.

The puzzle may be done by trial and error in which each piece is tried out in several places until the right one is found for it. In this case the child does not discover that some other distinction than form is necessary to aid him in placing the pieces, and his apparent compliance with the direction to look carefully at each piece and the opening before attempting to place it does not lead him to see the distinctive differences of color and matching of pattern which would accomplish the task. The mentally low grade child does the test by the trial and error method.

Table XIII shows the data obtained from the first four grades and the kindergarten.

TABLE XIII

Test II. Special Picture Puzzle

			Errors									
			0		1 and 2		3 to 5		6 to 10		11 or more	
Grade	Number	Average time	Number	%	Number	%	Number	%	Number	%	Number	%
Kdg.	22	3′-15″	0	0	1	5	5	22	9	40	7	31
I	21	2 - 8″	1	4	4	19	9	42	5	23	2	9
II	17	2′-11″	3	17	4	23	6	35	4	23	0	0
III	21	2′-17″	3	14	7	33	7	33	4	19	0	0
IV	21	2′-22″	7	33	10	47	3	14	1	4	0	0

This table shows that at the fourth grade the perceptive abilities of these children are such as to lead them to see the distinctions necessary for the accomplishment of the test with little error. At this grade 80 per cent of the children are able to do the test with less than three errors. Of the kindergarten children 71 per cent do it with six or more errors, an average of more than one error for each of the five pairs.

Of the fourteen feeble-minded children between eleven and

Fig. 3

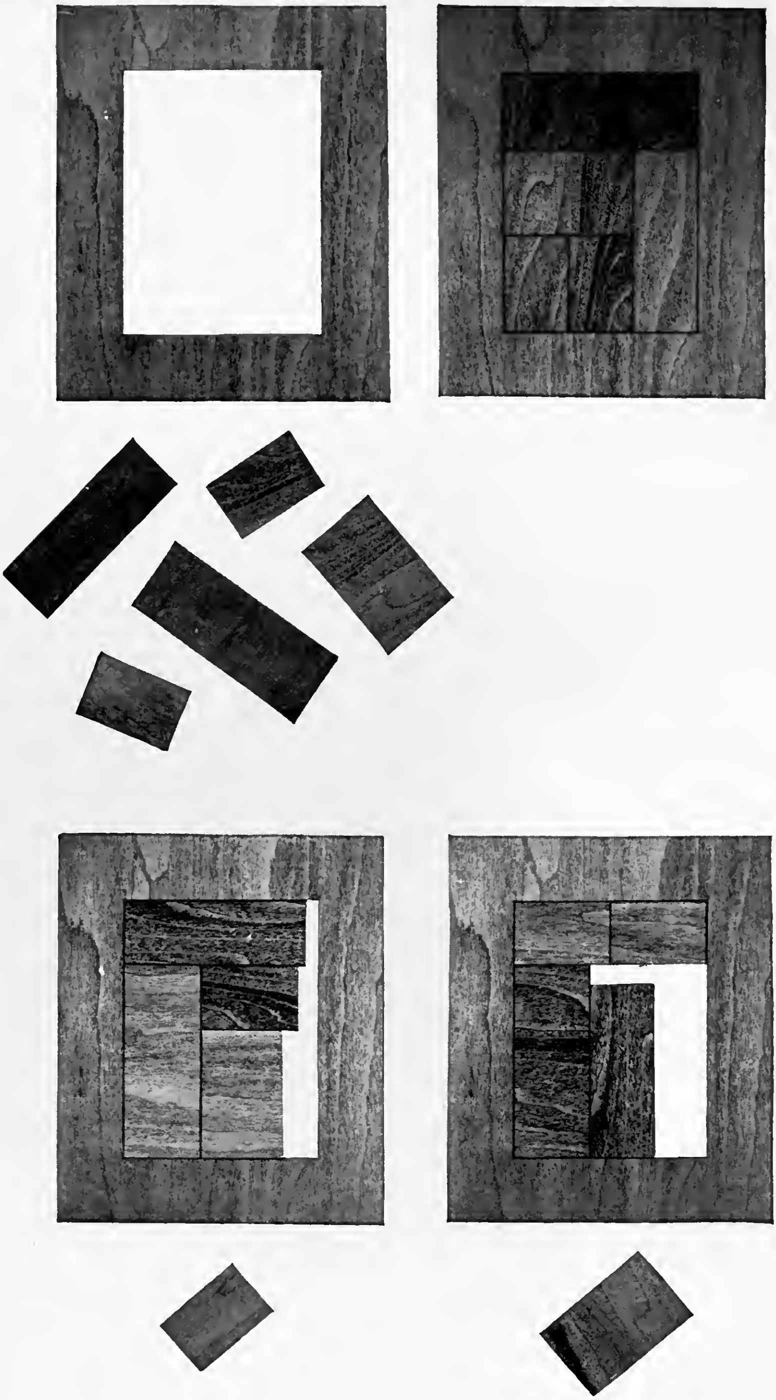


Plate II

Construction Test A

An example of a test which demonstrates planfulness and the powers of learning by experience. The illustration shows the test as presented, as completed, and two types of error.

From Individual Delinquents—Healy

thirteen years of age seen at the clinic, one did the test with two errors, two with five errors, nine with from six to twenty errors, and two were of so low grade as to be unable to attempt the test.

Table XIV shows the results of the test arranged according to age. This table shows that at the age of 9-6 years 75

TABLE XIV

Test II. Special Picture Puzzle. (By age)

Age	Number	Average time	Errors: 0		1 and 2		3 to 5		6 to 10		11 or more	
			Number	%	Number	%	Number	%	Number	%	Number	%
5- to 6-6	16	3'- 9"	0	0	0	0	2	12	7	43	7	43
6-6 to 7-6	13	2'-17"	2	15	4	30	4	30	2	15	1	7
7-6 to 8-6	27	2'-31"	3	11	3	11	10	37	9	33	2	7
8-6 to 9-6	23	2'-16"	2	8	8	34	10	43	3	13	0	0
9-6 to 10-6	20	1'-43"	6	30	9	45	4	20	1	5	0	0
10-6 to 11-6	6	1 -18"	2	33	4	66						

per cent of the children do the test with less than three errors, a marked advance over the preceding year when 42 per cent make as good a record.

Test III. Construction Puzzle A. This puzzle is made up of an outer frame and five pieces, two of which are identical in size and shape, which fill up the frame opening when properly placed. The test may be accomplished with a minimum of 5 moves, one for each piece. There are eleven possible errors without repetition. In giving the test, records of the number of errors and the time for its accomplishment are kept. In the final evaluation of results the removal of a piece from a right position is counted as error.

The frame is placed before the child with the pieces scattered on the table beside it and he is told that the pieces will exactly fill the frame if he finds the right way to put them in. The result is counted failure if the task is not accomplished in ten minutes.

Table XV shows the results of the test arranged according to grade.

TABLE XV

Test III. Construction Puzzle A. (By grade)

Grade	Number	Average time	Errors: Failure Number	Failure %	0 Number	0 %	1 to 5 Number	1 to 5 %	6 to 11 Number	6 to 11 %	12 or more Number	12 or more %
Kdg.	26	3′-10″	9	34	1	3	5	19	6	23	5	19
I	20	2′-18″	5	25	1	5	4	20	4	20	6	30
II	17	2′- 7″	0	0	0	0	7	41	5	29	5	29
III	21	1′-34″	0	0	1	4	10	47	6	28	4	19
IV	24	54″	0	0	3	12	15	62	6	25	0	0
V	22	1′- 6″	0	0	1	4	15	67	1	4	5	22
VI	24	43″	0	0	3	12	13	52	6	25	2	8

This table shows that the number of errors decreases until in the fourth grade 74 per cent of the children do the test with less than half the possible number of errors and may be considered as having planned the disposition of the pieces of the puzzle. Those in the 6 to 11 error column have made more than half the possible number of unrepeated errors and may be classed as having done the test by the method of *trial and error*. Those of the 12 error and the failure columns have failed to learn from the trial and error of their attempts and have repeated one or more errors. When this repetition begins in the child's performance the accomplishment of the test is then a matter of chance,—that is, the chance that he will hit upon the right relationship of the pieces. It is possible and probable that at some place in this repeated trial and error, learning and planning begin in the case of some children; but where they begin in any case can be only a matter of conjecture on the part of the experimenter.

The data of this table have been rearranged in table XVI to show the percentages of *planned, trial and error* and *chance* methods in the accomplishment of the test.

TABLE XVI

Test III. Construction Puzzle A

		Method					
		Planned		Trial and Error		Chance	
Grade	Number	Number	%	Number	%	Number	%
Kdg.	26	6	23	6	23	14	53
I	20	5	25	4	20	11	55
II	17	7	41	5	29	5	29
III	21	11	52	6	28	4	19
IV	24	18	75	6	25	0	0
V	22	16	73	1	4	5	22
VI	24	16	66	6	25	2	8

This table shows the increase of ability to plan the work of this test up to the fourth grade where it is highest, 75 per cent. There is a decrease of the chance method of performance to the fourth grade where it is the lowest.

Table XVII shows the same data arranged with reference to age and in accordance with the plan of evaluation of table XVI.

TABLE XVII

Test III. Construction Puzzle A. (By age)

		Method					
		Planned		Trial and Error		Chance	
Age	Number	Number	%	Number	%	Number	%
5 to 6-6	18	3	16	6	33	9	50
6-6 to 7-6	18	6	33	1	5	11	61
7-6 to 8-6	23	5	21	8	34	10	43
8-6 to 9-6	23	13	56	6	26	4	17
9-6 to 10-6	23	16	69	6	26	1	4
10-6 to 11-6	11	10	90	10	0	1	9
11-6 to 12-6	18	14	77	1	5	3	16
12-6 to 14-6	20	12	60	6	30	2	10

This table shows the increase of the use of the planned method until the age of 10-6 where it is highest, 90 per cent. The chance method decreases up to 9-6, where it is the lowest.

Of thirteen feeble-minded delinquent children between the ages of 10-6 and 14-6 seen at the clinic, five failed to do the test in ten minutes, one was of too low grade mentality to attempt it, six did it by the chance method with from 10 to 35 repetitions of error, and one did it by the trial and error method.

Since the results show that the test is not suitable for the testing of abilities for its performance above those of trial and error and chance for children under 8-6 where 82 per cent use a method superior to chance, it was given to the kindergarten children as a learning test. After the first performance of the test, the children were asked to do it again. Those who had failed to accomplish it were shown how. This showing consisted in such suggestions as led the child to place the pieces correctly once. Of the twenty-three children who were so tested, eleven repeated the test with no error; eight with one and two errors; one with three errors; and three by the trial and error method. The last mentioned group were asked to do the test again. One of them did it with no error and two with one error each.

Test IV. Construction Puzzle B.—This test consists of eleven pieces to be arranged to fit six openings. Three of the pieces are of identical shape and size and four others are paired in the same way. Two of the openings are the same in shape and size. Three of the openings sustain a one to one relationship with the pieces which will fill them, thus leaving three openings to be filled with eight pieces. In the accomplishment of the puzzle only one arrangement of pieces is possible, with the exception of the two identical openings which permit of an alternate arrangement of their respective pieces.

In doing the test one may perceive the relationship between all the openings and the pieces so perfectly as to accomplish the task with no error. In the actual performance of the puzzle it is usually accomplished by first placing the pieces which have a one to one relationship with their openings and thus reducing the task to its simplest form. As some of the pieces when put together will fill some of the openings but leave the task unaccomplished because there will be pieces and openings which do not fit, there is the possibility of trial and error which has a show of possibility of success. In this trial and error the child does not take into account in his work all the openings and all the pieces, but only the relationship of part of the openings and part of the pieces. In this type of reaction to

Fig. 4

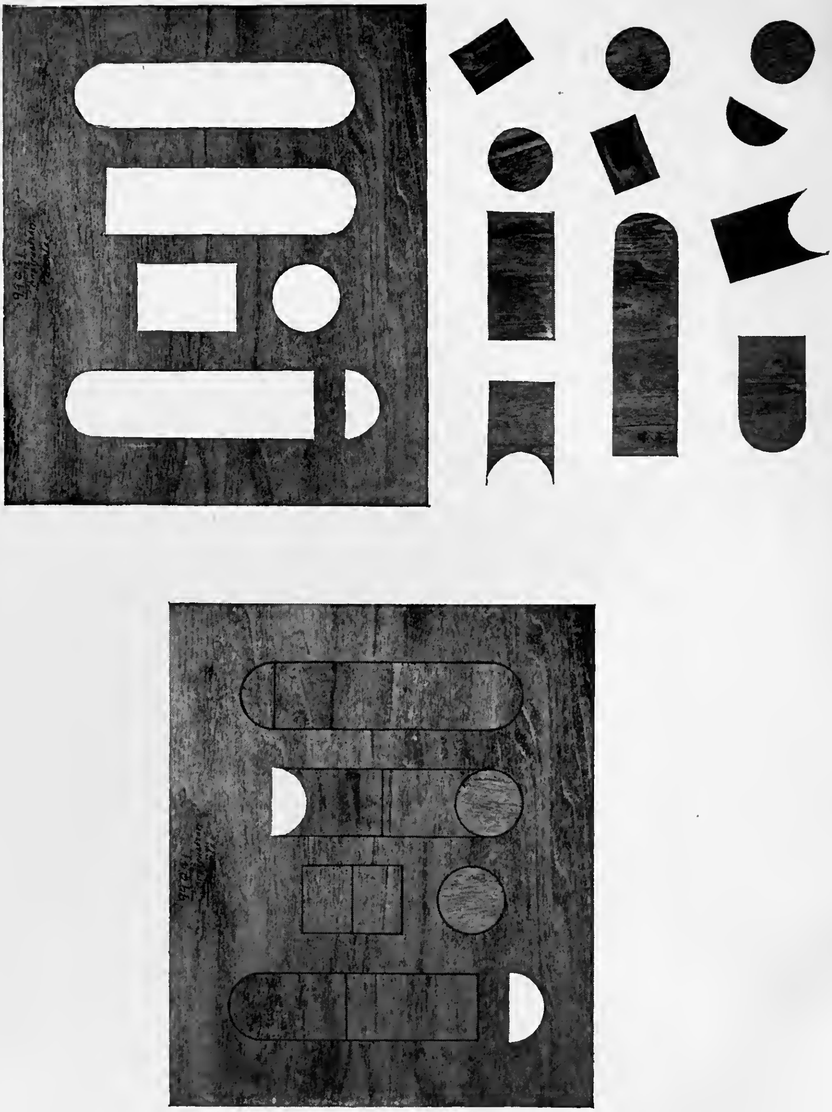


Plate III

Construction Test B

Another test for planfulness and learning by the method of trial and success. The illustration shows the test as presented, and one example of error in placing the pieces.

From Individual Delinquents—Healy
Courtesy Little, Brown & Co.

the test there are sixteen possible errors,—made up by counting all the different possible ways of placing all the pieces. In addition to these two types of performance there is another lower type of reaction in which pieces are placed without reference to their spatial relationship to the openings in which they are placed; as for example when a circular piece is put into a rectangular opening. This type of reaction if it does not fail to accomplish the test in the given time, does so by chance. In this type the only ability measured is the subject's recognition of success and his ability to keep before him the object of his work until it is attained. There is, of course, the lower type still with whom the test would not be a possible one, since the subject could not conceive the object of the task.

Table XVIII shows the arrangement of the data obtained with reference to grade.

TABLE XVIII

Test IV. Construction Puzzle "B." (By grade)

			Errors: 0		1 to 4		5 to 8		9 to 16		17 or more		Failure	
Grade	Number	Average time	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Kdg.	26	3'-51"	2	7	2	7	7	26	5	19	2	7	8	31
I	20	4'-23"	0	0	5	25	1	5	4	20	4	20	6	30
II	17	2'-15"	0	0	9	52	3	17	1	5	1	5	3	17
III	21	3'-13"	1	4	8	38	4	19	1	4	5	23	2	9
IV	24	2'-10"	6	25	9	37	5	20	1	4	2	8	1	4
V	22	2'- 8"	3	13	6	27	6	27	3	13	4	18	0	0
VI	24	2'-17"	4	16	9	37	5	20	4	16	2	8	0	0

As was done in the preceding tests, the data of this one have been arranged with reference to a qualitative standard. Those who made eight errors or less, that is, not more than half of the possible number of unrepeated errors are classed as having done the test by the *planned* method; those who made more than half the possible number of errors without repeating any, in the above table under the column "9 to 16" are classed as having done the test by the method of *trial and error;* those

who repeated errors or failed to perform the test in ten minutes are classed under the head of *Chance*. This is under the supposition that those who failed would have accomplished the test if given unlimited time. The data so arranged is shown in Table XIX.

TABLE XIX

Test IV. Construction Puzzle "B." (By grade)

		Method					
		Planned		Trial and Error		Chance	
Grade	Number	Number	%	Number	%	Number	%
Kdg.	26	11	42	5	19	10	38
I	20	6	30	4	20	10	50
II	17	12	70	1	5	4	23
III	21	13	61	1	4	7	33
IV	24	20	83	1	4	3	12
V	22	15	68	3	13	4	18
VI	24	18	75	4	16	2	8

This table shows that the use of the planned method was greatly increased at the second grade and is largest at the fourth grade, 83 per cent.

Table XX presents the same data arranged with reference to age.

TABLE XX

Test IV. Construction Puzzle "B." (By age)

		Method					
		Planned		Trial and Error		Chance	
Age	Number	Number	%	Number	%	Number	%
5 to 6-6	18	7	38	3	16	8	44
6-6 to 7-6	18	7	38	4	22	7	38
7-6 to 8-6	23	12	52	2	8	9	39
8-6 to 9-6	23	15	65	1	4	7	30
9-6 to 10-6	23	16	69	3	13	4	17
10-6 to 11-6	11	10	90	1	9	0	0
11-6 to 12-6	18	13	71	3	16	2	11
12-6 to 14-6	20	13	65	3	16	4	20

This table shows the increase of the use of the planned method up to 10-6 where it is highest, 90 per cent. The chance method decreases up to this point where it is lowest.

Of nineteen feeble-minded children above the age of nine years tried at the clinic after the test came into use there, six

were of too low grade to attempt the test,—that is, they could not conceive the object of the test and could not keep at work at it. Six failed to do it in ten minutes, two did it by the method of *chance,* two by *trial and error,* and three by the *planned* method. Of these three, one was 13-6 years of age and two were fifteen years of age.

The test was given to the kindergarten children in two ways. Those who failed were shown how to do the puzzle. The showing consisted of suggestions for the proper placing of the pieces which the child carried out. Each child who had not failed was asked to do the puzzle a second time, and those who had failed were asked to do it after being shown. Of the twenty-four cases, one child required to be shown a second time before learning to do the puzzle without error.

The test was then given as a test of the child's ability to readjust a learned content to a changed situation. The puzzle board was turned upsidedown and he was asked to do it again. In this situation, the pieces which were originally placed at the top of the board now had to be placed at the bottom. Of the twenty-four kindergarten children so tested, nineteen made less than two errors in doing the test in the altered position, and five made two errors or more.

It is characteristic of the feeble-minded child to do the test under the altered condition with the same amount, or more, of trial and error as in his first performance of the test; and sometimes after having once learned the test in one position he fails entirely to do it in the other.

The data for the above tables for this test were made up by counting as errors the wrong placing of any piece and the removal of a rightly placed piece from its proper opening. In some individual cases this method of evaluating results may be unjust. A child sometimes, finding that he can go no further, removes all the pieces already placed and begins again, though some he knows are right and he replaces them immediately.

The data are again rearranged below, made up by counting as errors only wrongly placed pieces and ignoring the rightly placed pieces removed for any reason from their proper open-

ings. According to this method the percentaged gradings become as follows:

Grade	Planned	Trial and Error	Chance
Kdg.	40%	18%	40%
I	38	14	47
II	70	11	17
III	66	9	23
IV	87	4	8
V	77	9	12
VI	78	20	0

Comparison of the percentages resulting from this method of reckoning error with those of Table XIX shows the former to be slightly more favorable to a grading above that of the chance method. Whether this method affords a more accurate judgment of the mental process is doubtful. In many cases the removal of a rightly placed piece is a positive error, for instance that of the half circle, since there is no other piece to fill the opening.

Test V. Puzzle Box.—In the previous tests the child had to analyze more or less complicated sets of spatial relationships or pattern matching. In this test he analyzes a set of functional relationships of a contrivance all of the parts of which are open to view, and involve no complex mechanical principles such as the lever, or pulley, etc. The test consists of a box which he is told he is to find a way of opening. The necessary number of steps to accomplish the result is seven. These steps consist of the loosening of the three inner rings from their confining posts, the removal of the staple at the back, the removal of the ring from the hook at the front of the lock, the removal of the hook itself from the lock and the raising of the lid. The arrangement is such that the steps must be accomplished in a certain order, and a tool must be used for the removal of the three inner rings. A long hook after the fashion of a shoe button hook is provided for this purpose.

In giving the test the box with the hook on top is placed lock side before and the child is told that he may look all over the box inside and outside and any which way it occurs to him to examine it to see if he can find a way to open it, and that he may do anything he thinks will help in opening it or use anything he

Fig. 5

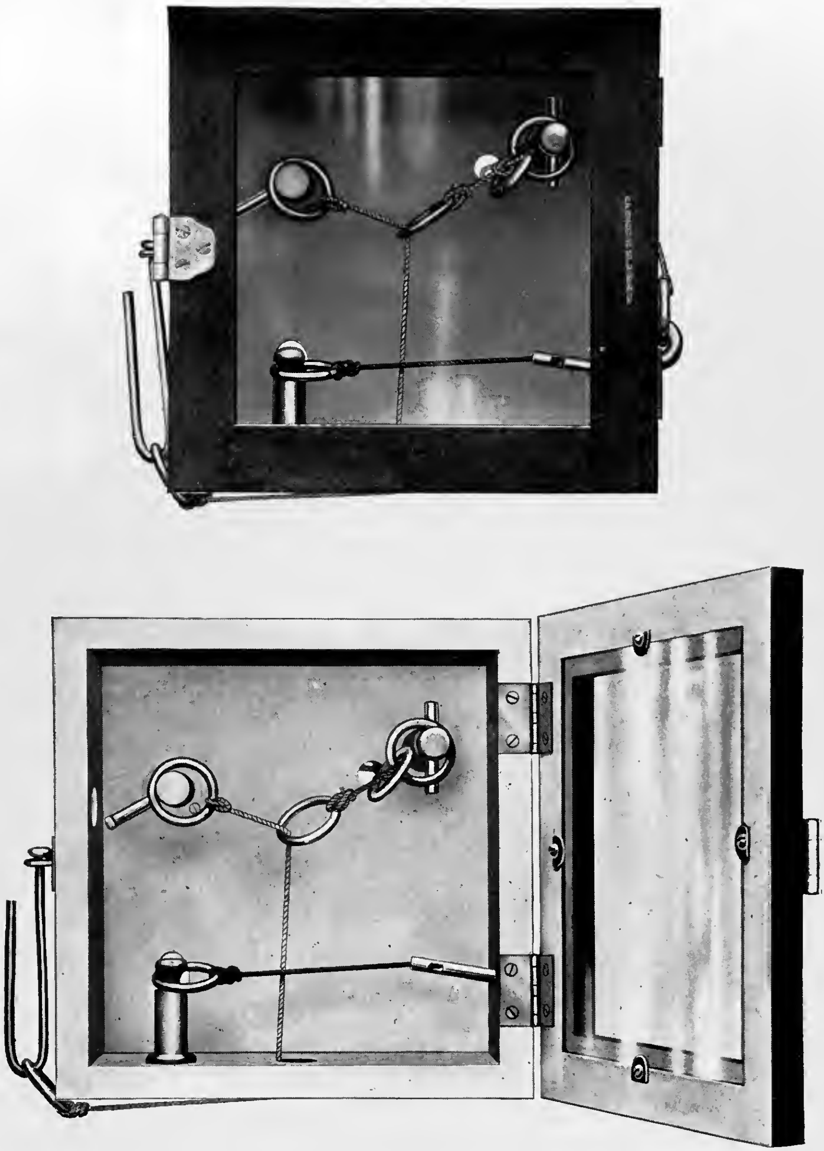


Plate IV

A Puzzle Box — our Test V

An example of a concrete problem to be reasoned out from perceived relationships. Each step to the solution, namely, opening the box, is plainly visible.

From Individual Delinquents—Healy
Courtesy Little, Brown & Co.

thinks will help. No further hint concerning the tool is given him, except in case he tries to accomplish step one, the first one it is necessary to manipulate, without the tool and leaves it to try something else since he can not succeed. He is then told that he may use the hook. He is then recorded in the classification under *tool idea*—. The child who is not classified under *tool idea*—sees for himself the need of the tool and uses it without suggestion or asks permission to do so. In the record of data the time which the child spends in studying the box without touching any of the fastenings is recorded, each step or attempt, and the time to accomplish the test. Wrong attempts are recorded as errors. The data for the time spent studying the box before proceeding to work were found to have no correlation with anything else. Whether the child spent a few seconds or several minutes in such study had no relation to his age or to the quality of his performance in doing the test after he began. Table XXI shows the data obtained arranged with reference to grade. The qualitative classification was made as follows: a child was placed in the *trial and error* column if after his manipulation of step one he made any other errors before accomplishing the opening of the box. He was placed in the *planned* column if, after the manipulation of step one, he made no further errors in opening the box. The one exception to this was the attempt to do step five, removing the ring from the hook at the lock, after step three. This error is permitted for the reason that after step three has been done the string holding the ring of step five is somewhat loosened and one can only know by trying it whether it is sufficiently loose to permit of the removal of the ring from the hook. It may also be explained here that error six is an attempt to push the hook through the lock with one movement instead of making the turn in the lock which is necessary to permit of its removal. In this classification the assumption is made that in the attempts preliminary to step one, (and no case has been seen in which some were not made), the child does or does not learn the arrangement of the fastenings and their relationship to each other. If his learning has been complete he

can then proceed without further error. If it has not been complete other errors are made, and he then can open the box only by a trial and error process. The usual procedure on the part of the child in this learning process is to take up the box and trace the fastenings back from the lock. He examines the lock and the ring of step five, follows it back to step four, and so on back to step one. He usually tries one or all of them before arriving at step one and sometimes does not follow the series through the first time but goes back to the lock or some other point and tries some of the fastenings again.

TABLE XXI

Test V. Puzzle Box. (By grade)

Grade		Method: Failed		Method: Trial and error		Method: Planned		Method: Tool idea		Average number moves		Average time	
	Number	Number	%	Number	%	Number	%	Number	%	Planned	Tr. and er.	Planned	Trial and error
*I	21	12	57	9	100	0	0	2	9	0	16		7'-23"
II	17	2	11	14	94	1	5	5	29	11	14	6'-52"	7'-56"
III	21	3	12	16	90	2	9	9	42	9	15	3'- 5"	6'- 2"
IV	24	2	8	15	70	7	29	12	50	9	14	5'-33"	6'-16"
V	22	0	0	8	36	14	63	3	13	9	13	2'-52"	4'-45"
VI	23	0	0	7	30	16	69	0	0	9	12	2'-52"	3'-54"

* A box similar to the one used here was tried with ten first grade children in another school. All of them failed to open it in 10 minutes.

Table XXI shows that for the children under the fifth grade from 70 to 100 per cent are able to do the test by a method not superior to that of *trial and error*. That the number of those who lack the tool idea in their planning of the test increases up to the fifth grade is due to the fact that it is taken account of only for those who succeeded in doing the test. In the fourth grade where the amount of failure is the smallest the lack of tool idea is greatest. The lack of the tool idea is generally associated with the trial and error method of doing the test; of the 31 children who lacked the tool idea, 28 did the test by the *trial and error* method; the three who did it by

the *planned* method belonged to the fourth and fifth grades. The last two columns of the table show the time correlation with the two methods of doing the test. The time decreases slightly as the grade progresses and for each grade the time for doing the test by the *planned* method averages less than the time for the trial and error method. This time correlation with grade is probably due to increase of motor ability. The two columns of the table preceding the last two show the correlation of number of moves with the two methods of work. The number of moves in each case is the number of errors plus seven, the number of correct moves necessary. After the second grade the average number of preliminary errors, found in subtracting seven from the average number of moves in each column, is two, and does not decrease. The number of moves decreases little for those who did the test by trial and error.

Table XXII shows the same data arranged with reference to age.

TABLE XXII

Test V. Puzzle Box. (By age)

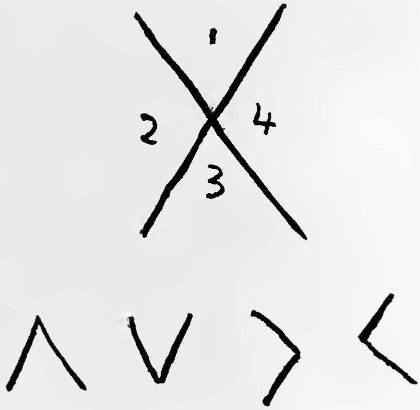
		Method									
		Failed		Trial and error		Planned		Average number moves		Average time	
Age	Number	Number	%	Number	%	Number	%	Trial and error	Planned	Trial and error	Planned
6-6 to 7-6	8	4	50	4	100	0	0	17		7'-39"	
7-6 to 8-6	27	7	26	20	100	0	0	14		7'-46"	
8-6 to 9-6	23	3	12	17	87	3	12	14	9	6'-55"	4'-21"
9-6 to 10-6	23	2	8	15	73	6	26	14	10	5'-33"	4'-43"
10-6 to 11-6	11	0	0	3	27	8	72	13	9	5'- 3"	3'-43"
11-6 to 12-6	18	0	0	6	33	12	66	13	9	4'-30"	2'-38"
12-6 to 14-6	19	0	0	8	42	11	57	10	9	3'-25"	2'-55"

This table shows that the use of the planned method for this test increases greatly at the age of 10-6 where it is the highest, 72 per cent.

Of twenty-six children between the ages of 10-6 and 17-6, judged at the clinic to be feeble-minded, and for whom a record for this test was recorded, eleven were of too low grade to attempt the test, ten failed in fifteen minutes to accomplish it and five did it by *trial and error.*

Test IX. Cross Line A.—This and the two following tests constitute a series of increasing difficulty, with the climax at the reasoning step of the third of the series, the code test. In this test the child uses representative material to accomplish the desired result. In the previous tests the child's work is continually checked up by the sense stimulus of the concrete material with which he works. This and the two following tests test his ability to analyse his memory of the figure which has just been drawn before him.

FIG. 6



The cross lines represented in the above figure are drawn before the child and he is told that in the space with the lines going upward and opening upward an I is placed; in the space opening out to one side a 2 is placed; in the space with its lines going downward a 3 is placed, and in the space opening out to the other side a 4 is placed. While he is being told this each space is outlined with the pencil and the number is written in. Then one of the elements of the figure is drawn at one side, and he is asked to tell which one of the spaces it is like. If he answers correctly, his reason for his answer

is asked. If he answers to the effect that its lines point like or open up like the one he has named, one may assume that he understands the problem, and go on with the next step in the test. If he answers wrongly, the figure is discussed further with him until he understands the nature of the analysis to be made.

There are cases of such low mentality as to be unable to comprehend the problem. When the child's comprehension of the problem is sure, the figure which has been drawn for him is covered, with the remark that he may now see if he can do the same thing with it covered up.

The elements are then drawn for him one by one and he is asked to number them. The question asked him is, *which space is this one like?* He is provided with a pencil to place the appropriate number. If he begins by making errors he can sometimes be led to find a method of recall for himself by the suggestion that he think of the covered up figure and see if he can remember what kind of space one is in, and two, and three and so on. If, after the four spaces are drawn and numbered there are errors, he is asked to draw the figure himself. In case of error one wishes to know if he has remembered the figure and its scheme of numbering incorrectly, but has analyzed correctly according to his memory of it, or if he has remembered it correctly and analyzed it incorrectly. If he has analyzed it correctly as he has remembered it he is placed in the list of those who have succeeded at the first attempt, since it is his ability to do the analysis correctly that is to be tested. If he has not analyzed correctly but has remembered correctly, he is told that he did not number the spaces correctly at first and that he may try again. If he has neither analyzed nor remembered correctly he is permitted to look at the original figure and then is asked to draw it again, and is given as many trials as is necessary to learn to draw the figure and number it correctly from memory. The writer has found no child who has been able to comprehend the problem of the test who could not learn to draw and number the figure correctly with as much as three such trials. If, after the second attempt at

analysis from memory, he still fails to number all the elements correctly he is again asked to draw the figure and the process is repeated as before. He is given four such trials at the analysis before being classed as failure. Table XXIII shows the data obtained with this test arranged with reference to grade. It cannot be given to kindergarten children because of their unfamiliarity with written numerals.

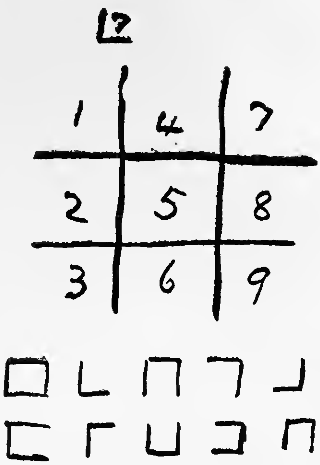
TABLE XXIII

Test IX. Cross Line Test A. (By Grade)

		Failure		Succeeded							
		Fourth trial		First trial		Second trial		Third trial		Fourth trial	
Grade	Number	Number	%	Number	%	Number	%	Number	%	Number	%
I	20	2	10	12	60	3	15	3	15	0	0
II	17	2	11	14	82	1	5	0	0	0	0
III	21	0	0	19	90	1	4	1	4	0	0
IV	25	0	0	21	84	1	4	1	4	2	8
V	22	0	0	22	100	0	0	0	0	0	0
VI	24	0	0	24	100	0	0	0	0	0	0

The table shows that the percentage of children between the first and the sixth grades who fail to do the test is negligible, and that after the first grade the percentage who need more

FIG. 7



than a first trial is negligible. Since the results for the grades are so uniform an age table is omitted.

Test X, Cross Line Test B.—The procedure for this test is, so far as its own circumstances permit, like that of the preceding test. The figure is constructed before the child, and the spaces in which 1, 2, and 3 are placed are outlined while being numbered. He is then given four trials, proceeding as prescribed in the preceding test. The results are evaluated as in the preceding test.

Table XXIV shows the data of this test arranged with reference to grade.

TABLE XXIV

Test X. Cross Line Test B

		Failure		Succeeded							
		Fourth trial		First trial		Second trial		Third trial		Fourth trial	
Grade	Number	Number	%	Number	%	Number	%	Number	%	Number	%
I	20	6	30	8	40	3	15	2	10	1	5
II	17	2	11	11	64	1	5	2	11	1	5
III	21	1	4	17	80	3	14	0	0	0	0
IV	25	0	0	20	80	1	4	2	8	2	8
V	22	0	0	18	81	3	13	1	4	0	0
VI	24	0	0	24	100	0	0	0	0	0	0

This table shows that after the first grade the percentage of failure is negligible, and that after the third grade there is no failure in doing the test. After the second grade from 80 per cent to 100 per cent are able to do the test at the first trial. Before the second grade the percentage of children who need more than a second trial is negligible.

The writer's further experience with this and the preceding cross line test has led to the opinion that two trials constitute a sufficient test of the child's ability to perform this type of mental process. The drawing of the figure by the child after the first unsuccessful attempt shows whether the failure is due to his having forgotten the figure and its number arrangement.

It gives him in an added experience, the kinaesthetic, whatever it may be worth in controlling his imagery for the second trial. The practice effect which more repetition may have upon the result is eliminated with the fewer trials.

Test XI. Code Test.—To this test has been added a step which was not involved in the test as described by Healy and Fernald. This added step requires the subject to use his experience with the material of the two preceding tests in a new way. It is a test in reasoning which controls the material which the child uses for the new product and which is not the result of previous learning as is the case with many other reasoning tests in use.

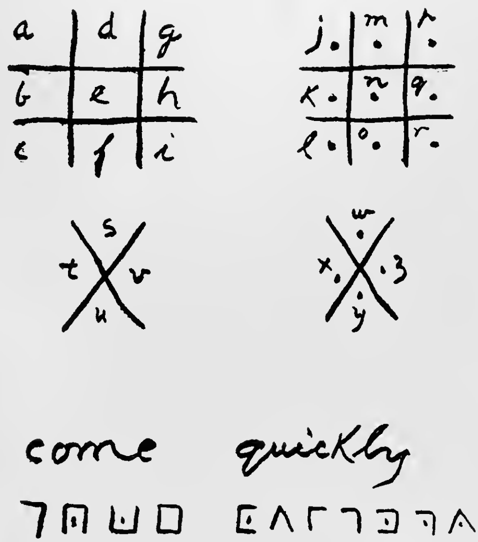
Bonsel (21) used in testing the reasoning ability of children (1) arithmetical problems: *If three-quarters of a gallon of oil costs 9 cents what will 7 gallons cost? What number subtracted 12 times from 30 will leave a remainder of 6?* (2) The completing of sentences to agree with the fact implied in the sentence:—*always comes in the last week of December. The flesh of cattle used for food is called—.* (3) The selection of alternate statements to agree with the fact implied in the statement: *Days are* *longer* / *shorter* *in summer than in winter. Men are usually* *stronger* / *weaker* *than women.* (4) Opposites: *day, asleep.* (5) Selective judgment, in which a number of reasons are given to show why New York has become a greater city than Boston; why oak is superior to pine for the making of furniture, etc., and the child selects those which are in his judgment the most adequate. (6) Literary interpretations: *This little rill, that from the springs of yonder grove its current brings, etc.* All of these tests involve previous instruction, and it is possible that they may test nothing more than the thoroughness of the child's assimilation of such instruction. It is also possible and even probable that one's ability to learn in this way the reasoning processes taught by others is positively correlated with his own ability to reason, and thus a measure of the former becomes an indirect measure of the latter. None of the Bonser tests,

however, control the material or the process which is used in the act of reasoning. In doing the tests the child may never have reasoned at all, but have relied only upon information previously acquired and used. Nothing else could be the case with tests two, three, four and five.

The procedure for Test XI must necessarily be adapted to the interests and temperament of the child to whom it is given. Only general directions for giving it can be suggested. The procedure adopted by the writer is as follows:

One says to the child, "You know that in war time, when two armies are fighting each other, the generals send out spies to find out the secrets of the enemy's army, and sometimes the spy must write what he has found in a secret message to his general. When he writes a secret message, of course, he cannot write it in the way in which we ordinarily write a letter because it might fall into the hands of the enemy and betray him. He must have a secret way of writing so that only the general and himself will be able to read the message. Now, I will show you something from which we can get a kind of secret writing. The code is here constructed before him while he gives attention.

FIG. 8



When the four figures are constructed in which the letters of the alphabet must be placed, the child is asked to repeat the alphabet while they are being put in the spaces. This insures his attention to the rather long process in hand, and also shows whether he knows the alphabet serially and hence might be expected to do the second part of the test. Some children do not know the alphabet in its correct serial order.

After the construction has been completed, then he is asked, "Now, what could one get from this to use instead of the writing letters of the alphabet for his message? If, for instance, he were going to write a word that began with A, what could he use instead of A, and instead of B, or C or any other letter he might need to use in writing his message?"

The children frequently make suggestions which have no relation to the construction before them. They will say he may use numbers instead of letters, or they offer the Morse code, or some similar scheme with which they are already familiar. After each wrong suggestion it is pointed out to them that their scheme has nothing to do with the one before them, and could not be derived from it, which they, of course, readily admit. The writer permits two such suggestions, giving them an opportunity to make a third before classing the child among the failures for the reasoning step of the test. Those who succeed in seeing the correct process for the code writing are classed in the column, "Idea +" in Table XXV below. Those who fail through having made only wrong suggestions, or having made none at all, are placed in the column, "Idea—." Those who have no suggestions to make are allowed to think about it, and urged to think about it until they themselves declare that they can see no way of getting the secret alphabet from the scheme before them. Those who fail are then shown that each letter may be represented by the space in which it stands, and are asked to write the symbol which would stand for G, the one which would stand for P, the one which would stand for V, and the one for Z in order to bring out the idea of the relation of the dot to the scheme, and also for the purpose of giving a slight practice. Those who have succeeded are also given this same practice.

The figure is then covered, and the child is asked to write the message, "Come quickly," previously written on the page before him. He is told to take as much time as is necessary to enable him to write it without errors.

Table XXV shows the data obtained from this test arranged according to grade.

TABLE XXV

Test XI. Code Test

Grade	Number	Idea + Number	Idea + %	Idea — Number	Idea — %	Idea? Number	Average number errors
II	16	3	18	13	81		8
III	21	10	44	9	42	2	7
IV	25	15	60	9	36	1	4
V	22	15	68	6	26	1	2
VI	24	12	50	10	40	2	3

This table shows that after the third grade more than 50 per cent of the children succeeded in doing the reasoning step of the test. In the column "Idea?" was placed those children who had seen this code previously. After the third grade they are able to attend to this rather long and complex process of analysis of mental imagery to such an extent as to average not more than four errors or 36 per cent out of the possible eleven.

The second grade showed itself almost wholly unable to do the reasoning step of the test, and was rather uninterested in the test itself. The necessity for a secret means of communication is quite outside the range of experience of these children, since for them writing itself has not yet wholly ceased to be a mysterious process.

Of thirty-two children between the ages of 8-6 and 17-6, classified as feeble-minded at the clinic, twelve were of too low grade mentally to undertake any of the three above described tests. Twelve failed in Tests IX and X. With Test IX, four succeeded at the first trial, two succeeded at the second trial, one succeeded at the third trial and one succeeded at the fourth trial. Among those who succeeded with Test IX two succeeded at the second trial with Test X.

The Code Test was not attempted with any of these children

because of their difficulty with the two tests which necessarily precede it.

Test XV. Association of verbal opposites.—The list of words used for this test is as follows:

Good	Big	Happy	Sick	Empty
Outside	Loud	Cheap	Glad	Many
Quick	Black	Dead	Thin	Above
Tall	Light	Rich	War	Friend

The child is given some trial practice with as many words outside of this list as is necessary to show that he has gained the correct idea of what is desired of him in this test. He is asked to say the word which means just the opposite of the word which will be pronounced to him, as quickly as he can think of it. The time is recorded with a stop watch. With this test, as with many others, the absolute time of response is, within rather large limits, of less importance than the character of the response. The data of the test comprises three things: The reaction time, the errors made in response, and the failures. An error is a reaction which is not in idea an antonym of the stimulus word. Among defective individuals it is very common to find a lack of control of the associations which may be aroused by any stimulus word. The normal individual will repress the wrong associations and give only the one which is desired. The defective individual instead of giving an antonym will give a synonym, or anything else which may come immediately to his mind as an association with the stimulus word. The defective child often, too, will embody his reaction word, whether correct or not, in an entire sentence. The normal child inhibits all words but the one which is desired. In recording the data any such response which was not in its meaning an antonym of the stimulus word, was recorded as error. Care was taken, however, in each case, if the reaction word was not of the same part of speech as the stimulus word or, if it were not the classical antonym of the stimulus word, to determine whether in the child's mind it was an antonym. This is especially desirable in testing children from homes where a foreign language is spoken, or from parochial schools. For

instance, the classical antonym for empty is *full;* children frequently respond with the word *filled;* the classical antonym for above is *below;* a frequent response is *down;* the classical antonym for sick is *well;* a frequent response from children is *better.* Slang words are always recorded as correct. For instance, *good* gets the frequent response *bum.* One might go on to enumerate many other instances in which the child's mental action was controlled in the desired way, but in which response was modified by educational experience.

A failure is a lack of response of any sort within ten seconds after the pronunciation of the stimulus word. With failure it is desirable to know what is the reason for the failure,—whether it is lack of knowledge, or whether the child could not bring about the right association. To determine this, questions may be asked. For instance, if he fails to respond at all to the word loud, one may ask him, "If the noise is not loud what kind of a noise is it?" and the question may be put in various ways to bring about in his own mind the correct association. If in this way one elicits the correct response, then he is recorded as failure because of slow response. If the correct response cannot be elicited, he is then recorded as failure from lack of knowledge.

Table XXVI shows the data obtained from this test arranged according to grade. The failures were recorded as such only if they were failures because of slow response, and not because of lack of knowledge. The most common failures for lack of knowledge were to the stimulus words *war* and *friend.* Younger children have not had sufficient experience in reading or conversation to know the opposite of war. The response to the stimulus word *friend* is frequently a word indicating a relative or member of the family, showing that in the child's mind there are two classes of persons with whom he has personal relationship, those belonging to the family and those outside of the family who are friends.

TABLE XXVI

Test XV. Opposites Test. (By grade)

			Errors								Failures							
			0		1 & 2		3 & 4		5 or more		0		1 & 2		3 & 4		5 or more	
Grade	Number	Average time	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
I	20	2⅗	2	10	12	60	4	25	1	5	3	15	10	50	6	30	1	5
II	16	2⅗	8	50	6	37	1	6	1	6	6	37	6	37	3	18	1	6
III	21	2⅗	6	28	12	57	3	14	0	0	3	14	11	52	4	19	3	14
IV	23	2	14	61	8	34	1	4	0	0	11	47	9	39	2	8	1	4
V	22	1⅘	17	77	4	17	1	4	0	0	15	67	7	31	0	0	0	0
VI	24	1⅗	21	87	3	12	0	0	0	0	13	54	10	41	1	4	0	0

The table shows that, beginning with the second grade, the percentage of children who make more than two errors become negligible; beginning with the fourth grade, from 61 to 87 per cent make no errors. On the failure side we see that, beginning with the fourth grade the percentage of those who make more than two failures becomes negligible, and at the fifth grade more than fifty per cent of the children make no failures.

Table XXVII shows the same data arranged with reference to age. The same statement with reference to errors as above

TABLE XXVII

Test XV. Opposite Test. (By age)

			Errors								Failures							
			0		1 & 2		3 & 4		5 or more		0		1 & 2		3 & 4		5 or more	
Age	Number	Average time, secs.	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
6-6 to 7-6	8	2⅕	0	0	5	62	3	37	0	0	0	0	6	75	1	12	1	12
7-6 to 8-6	24	2⅕	9	37	11	45	2	8	2	8	6	25	11	45	6	25	1	4
8-6 to 9-6	23	2	9	39	11	47	3	12	0	0	9	39	9	39	3	13	2	8
9-6 to 10-6	23	1⅘	15	65	8	34	0	0	0	0	9	39	11	47	2	8	1	4
10-6 to 11-6	11	1⅗	6	54	4	36	1	9	0	0	4	36	5	45	1	9	1	9
11-6 to 12-6	17	1⅖	13	76	3	17	1	5	0	0	11	61	6	35	0	0	0	0
12-6 to 14-6	20	1⅖	17	85	3	13	0	0	0	0	11	55	8	40	1	5	0	0

may be deduced from this table beginning with the age 8-6, and for failures beginning with the age 9-6. At 11-6 more than 76 per cent of the children make no errors and 61 per cent no failures.

Of thirty feeble-minded children between the ages of 9-6 and 17-6 seen at the clinic, twenty-one were unable to understand the import of the test and so control their associations as to make a record for it; the defective child fails to inhibit the wrong association, responds with a whole sentence, goes off on a tangent of discussion with each stimulus word, or responds with absolute silence. Of the nine remaining, four made two errors or less, two made either three and four errors, and three made five or more errors. Five made two failures or less, one made three failures, and three made five or more failures.

Text XII, Memory from Visual Verbal Presentation.—A typewritten sheet like the ordinary printed page, containing the following selection is placed before the child:

If a man finds that the house is on fire, he should first look to see if it is a large fire. If it is a small one, he should quickly pour water on it or smother it. But if it is large, he should run to the fire alarm box, calling out fire to the other people in the house. Then he should go back and help old or sick people or little children to escape from the burning building. When all the people are out, if there is time he may save valuable things such as money or jewelry. Then when the fire engine comes, he may keep the crowds or curious people out of the way so that the firemen may work more easily.

The child is told that he may read this selection to himself once and then hand it to the experimenter and tell what he has read; just as nearly like that which he read as he can remember; but that if he can not remember it precisely he should not be worried about it but give it as best he can. The request to hand it back as soon as he has finished reading, is to let the experimenter know that he has finished, and to discourage his attempting to read it a second time, as was found sometimes to be the case when this order was not given. He is also told that if there are any words which he does not know, if he will merely point to them they will be pronounced for him. It was found with the children of this school that those of the second grade and above found very few words which they could not pronounce.

The experimenter uses for permanent record a printed sheet with space sufficiently wide so that changes in the text as rendered by the child may be written in, or words or phrases omitted in his rendering may be crossed out.

Permanent Record Sheet of Test XII

If a man finds that the house is on fire
he should look to see if it is a large fire
if it is a small one
he should pour water on it
or smother it
but if it is large
he should run to the fire alarm box
calling out fire
to the other people in the house
then he should go back
and help old or sick people
and little children
to escape from the burning building
when all the people are out
if there is time
he may save valuable things
such as money or jewelry
then when the fire engine comes
he may help to keep the crowds of curious people out of the way
so that the firemen may work more easily.

Table XXVIII shows the data, arranged according to grade, obtained from this test. The data are the number of items the child remembers. What is considered an item is indicated by the length of line in the record sheet above, each line constituting one item of the passage. A judgment is made in each case as to whether the child was *verbally accurate, approximately verbally accurate,* or made no attempt to be verbally accurate. The correctness of the sequence of items is also noted. He is noted in the column, *Sequence correct* if there is not more than one detail misplaced in the selection. He is put down in the column, *Sequence incorrect* if more than one detail is misplaced in the selection. Following is an example of an approximately accurate verbal reproduction. It may be remarked here that there were none absolutely accurate.

"If a man finds his house is on fire, he must first look to see if it is a large fire. If it is a small fire, he should pour water on it to smother it; but if it is large, he should run to the fire alarm box and call out 'Fire!' to the people. Then

he must go to help old or sick people out from the fire. Then, if there is time, he may bring out jewelry. Then when the fire engine comes he may help to keep back the crowds of curious people."

Following is another case, which was put in the column *No attempt at Verbal Accuracy:*

"If a house should catch on fire, and the man should see it, he should look to see if it is a large fire. If it is a small fire, he should pour water on it or smother it; but if he finds it is large, he should run as fast as he could to the fire alarm box and ring for the firemen. Before the firemen come, if the fire isn't very bad he first saves the sick who could not get out. Next, get the children out, and when the firemen come keep the crowds back so that the firemen can work."

Following is another example of a reproduction placed in the column *No Attempt at Verbal Accuracy.* It is not so inaccurate as the preceding one.

"If a man sees a fire, he must first look to see if it was a big one or a small one. If it is a small one, he should throw water on it; but if it is a big one, he should run to the fire alarm box and call up the fire engine. Then he should go back and see if he can do anything for sick or helpless people. After all the people are taken care of he should save money

TABLE XXVIII

Test XII. Memory from Visual Verbal Presentation

		Details Remembered						Accuracy				Sequence			
		20		19 to 15		14 or less		Approximate		No attempt		Correct		Incorrect	
Grade	Number	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
II	17	1	5	7	41	9	52	10	58	7	41	16	94	1	5
III	21	1	4	12	57	8	38	19	90	2	9	19	90	2	9
IV	24	0	0	15	62	9	37	23	95	1	4	23	95	1	4
V	22	3	13	16	72	3	13	14	63	8	36	19	86	3	13
VI	24	1	4	15	62	8	33	22	91	2	8	22	91	2	8

and valuable things. Then when the fire engine comes, he may help to keep the curious people away from the fire, so that the firemen may work more easily."

The data of Table XXVII show that beginning with the third grade more than 61 per cent of the children are able to recall not less than fifteen items of the twenty they have read. These data are in striking contrast with those which Binet obtained with his visual verbal memory test of the 1908 series. He found that two items constitute the normal for eight-year-old children. The data which Goddard (15) derived from the same test led him to conclude that it was too difficult for eight-year-old children. The material used for the Binet test was as follows:

New York, September 5th. A fire last night burned three houses in Water Street. It took some time to put it out. The loss was fifty thousand dollars, and seventeen families lost their homes. In saving a girl who was asleep in bed, a fireman was burned on the hand.

The difficulty with the Binet test probably lay in the unfamiliarity of much of its material. In such case the child's attention is often so much engaged with the matter which is unfamiliar to him that he fails to organize that part which is familiar to him, and so presents the appearance of failure when such is not really the case. The newspaper type of beginning of the paragraph could only confuse a non-newspaper reading child; the unfamiliar street name, and the unfamiliar quantity, fifty thousand, followed by another number in enumerating the loss, may detract attention and prevent an organization of the story into a complete whole.

The table shows that all the children were approximately accurate in their reproduction of the selection read, and that the number of children who reproduced the selection with errors in the sequence of items is negligible throughout, with the exception in each case of the fifth grade. This grade presents a rather large percentage of children who make no attempt at verbal accuracy and who made errors in the sequence.

Test XIII. Memory from Auditory Verbal Presentation. The following passage is read to the child four times. He is told

before the reading that he must listen very carefully and then repeat the story as nearly as he can as it was given to him, but that if he cannot remember it precisely he should give it as well as possible.

If a sailor on the ocean is shipwrecked in a wild country, he must first look for water to drink; then he must find a place to sleep, where wild animals can't get at him; and after that he can take time to look for food, but he must be careful not to eat poisonous berries or fruit. Next, he had better hunt for other people on the land, and put up a flag to stop ships which may be going by.

Permanent Record Sheet for Test XIII

If a sailor
on the ocean
is shipwrecked
in a wild country
he must first look for water to drink
then he must find a place to sleep
where wild animals won't get at him
and after that he can take time to look for food
but he must be careful not to eat poisonous berries or fruit
next he had better hunt for other people on the land
and put up a flag
to stop ships which may be going by.

The same data are kept for this passage as for the one given above. Following is an example of a passage classed as *No Attempt at Verbal Accuracy:*

"If a sailor is shipwrecked, he has to be careful to see that he has water, then to see that he sleeps where wild animals won't get at him, and then he has to look for food, and be careful not to eat poisonous berries or such things, and then he has to look for other people, and put up a flag to stop ships going by."

The following is an example of a reproduction placed in the *approximately verbally accurate* column:

"If a sailor on the ocean is shipwrecked in a savage land, he must first look for water. Next, he must find a place to sleep where wild animals won't get at him. Then he may look for food, but be careful that he does not eat poisonous berries or fruit. Next, he must look around for other people on the land, and put up a flag to stop ships going by."

Table XXIX shows the data obtained from this test:

TABLE XXIX

Test XIII. Memory from Auditory Verbal Presentation

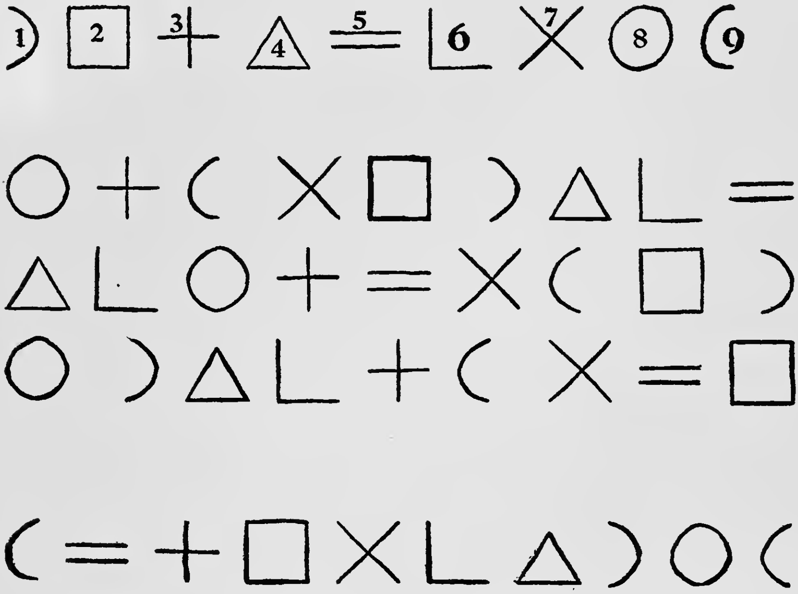
		Details Remembered						Accuracy				Sequence			
		12		11 to 9		8 or less		Approximate		No attempt		Correct		Incorrect	
Grade	Number	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
I	13	1	7	10	77	2	15	5	38	8	61	3	23	10	77
II	17	2	12	13	76	2	12	15	88	2	12	16	94	1	6
III	21	4	19	16	76	1	5	20	95	1	5	20	95	1	5
IV	24	6	25	18	75	0	0	23	96	1	4	23	96	1	4
V	22	9	31	13	59	0	0	16	73	6	3	19	86	3	13
VI	24	3	12	19	79	2	8	22	92	2	8	24	100	0	0

It may be observed from the table that throughout the grades the number of items omitted in the reproduction are negligible. The children in general are able to remember nine or more of the twelve items presented them. After the first grade, the percentages of children who do not attempt to be verbally accurate is negligible, and after the first grade the percentage of those who do not get the sequence correct is negligible.

Test VIII; Learning Test—Arbitrary Associations.—The material for this test consists of nine geometrical figures placed at the top of a sheet and numbered. Below these are the figures reproduced each one three times, without the corresponding numbers; below these is another row of the geometrical figures without the numbers. Figure 9 is a reproduction of the sheet for this test. It is laid before the child and he is told that at the top of the page he will see a set of figures or little pictures each with a number, and that below are the same kind of figures but without the numbers, in which he is to place the number of the same figure in the top row. He is then asked, "What number goes in the first figure?" A correct response shows his understanding of his task. Many children do not at first understand the instructions and begin to number the figures serially, 1, 2, etc. In such case the instructions are repeated. When the three compact lines designed for that purpose are numbered they are covered and the child is told

that he may number the remainder from memory. Healy and Fernald give an additional instruction: "When he has done this he is told to study well the top line until he thinks he knows it." This procedure is not followed by the writer because it introduces a confusion in the comparison of results. Some children take much time and some take only a glance without attention to the instructions. This case is a clear illustration of the fact of the unreliability of time measure as a measure of mental process. What the child is doing mentally in what-

Fig. 9



ever time he does take can only be guessed. If the sheet is covered as soon as the last figure is numbered the learning conditions will be made uniform. This test is, of course, only possible after the child has gained sufficient practice in writing numerals as to make the process automatic and thus free the attention from this part of the task to that of fixing the desired associations. The test, therefore bears some relation to the curriculum. It can not be given until after such time as this practice has been gained in the school. Since the following table shows it to be a suitable test for the first grade child it

would probably be suitable for younger children if it were devised in a form which would do away with the necessity for such skill.

The scoring takes account of errors of perception—that is the errors made in numbering the figures from the model line—and the errors of memory. Table XXX shows the results of this test for the first four grades.

TABLE XXX

Test VIII. Learning Test—Arbitrary Associations. (By grade)

		Errors of Perception				Errors of Memory				
		No errors		1 or more errors		No errors		1 or more errors		
Grade	Number	Number	%	Number	%	Number	%	Number	%	Av. Er.
I	*20	18	90	2	10	11	55	9	45	2+
II	17	13	76	4	23	12	70	5	29	2+
III	21	21	100	0	0	17	80	4	19	1+
IV	22	22	100	0	0	19	86	3	13	2+

* Of seventeen first grade children of another private school, none made errors of perception, two made two errors each of memory.

The table shows that throughout, the errors of perception are negligible and the errors of memory are negligible after the second grade. The average error of those who made errors are not more than two.

It may be noticed that in the line for memory numbering one of the figures is repeated. This forms an interesting sort of trap for the unwary type of mind which is always exhibited by the defective individual. This type of person will give it some other than the proper number, not seeing that he has given different numbers to the same figure; or when he comes to it, he looks over his past work and finds that he has used all the numerals up to ten and then inserts that. The normal child often shows an ability to help his memory which is never exhibited by the defective individual. When the former has forgotten the appropriate number for one figure he will voluntarily or upon suggestion go on and number the others which he does know; then he will look over his work again and find

which numeral he has not yet used and place that in the forgotten figure. Questioning the child will often bring out the process used by him in determining the forgotten item. An example is that of a nine-year-old boy. He was asked, "How did you know that was the right number?" "I guessed." "How?" "I looked and saw that I did not have an eight anywhere and I knew that must be the number." The defective individual has no way of helping himself out in such an emergency.

VII

CORRELATION OF THREE TESTS WITH SCHOOL GRADE

The tests which have been discussed above were the ones chosen for standardization, leaving out for lack of time the few which had proved of least value in the work of the clinic. In order to show what correlation exists between these tests and general ability, three were chosen to be correlated with school standing of children of a uniform age. School standing may be taken as a rough measure of a child's general ability to learn, because of the varied character of school work in a city school. The curriculum contains reading, writing, arithmetic, and the application of these three tools in the acquisition of organized bodies of knowledge such as history, geography, etc.; and it contains handwork in varying degrees of complexity to suit the various grades. In the Chicago schools a child is not retained in a grade for a second term if he fails in no more than one of the required subjects of that grade. This rule keeps the child progressing in spite of the lack of some one specialized ability or interest. The rule can, however, be of significance only for the grades above primary work. A child who can not learn to read, for instance, could make little or no progress from grade to grade since all the work of the school with the exception of handwork rests upon reading as a foundation. In the case of the defective child school grade may not indicate a true measure of his mental ability,—at least it is not always a measure of his accomplishments in the work of the school. Because the number of special rooms for defective children is insufficient for the supply many have to be kept in the regular grades. When a defective child in such circumstances becomes too large to sit in the seats of the grade appropriate to his school accomplishments, or for some other reason, he is sent to another room where he may more com-

fortably be taken care of. It is seldom, that a defective child is found in the fifth grade or above. His progress through the school is at the rate of two years or more to a grade and at the age of fourteen he is found no higher than the fourth grade. On the other hand, among the foreign neighborhoods, many children are in low grades by reason of late entrance into the public school. A foreign born child, coming to America at the age of twelve, must, of course, be placed in the first or second grade to learn to read. Other children, by reason of physical handicaps, may be in grades which do not measure, perhaps, innate ability, but only what they have been able to accomplish under the circumstances. Poor vision or hearing may constitute handicaps to learning in the school, when the child's innate ability to learn is good. The school grade is not, therefore, an exact measure of mental ability.

With the above qualifications in mind the following tables may be taken only as indications of an existing correlation between the tests chosen for the purpose and general ability as indicated by the school grade. The tendency to positive correlation is clearly shown.

The tests which have for prerequisites the smallest amount of formal training and knowledge were selected for the purpose of correlation with school grade of the children from 12-6 to 13-6 seen in the clinic. All of these children came from public or parochial schools. Children of this age who have begun school at the legally required age of seven and have progressed normally through the school a grade a year should be in the seventh grade. Those who began at six, the legally permissible age, should be in the eighth grade. The cases were scattered from the first to the eighth.

Table XXXI shows the data obtained from Test V, the puzzle box, arranged with reference to the qualitative reaction already discussed.

The table shows that beginning with the sixth grade practically all do the test by the planned method, and that below the fourth grade practically all fail. Those below the fifth grade are two years and more retarded in their school work.

TABLE XXXI

Test V. Puzzle Box. (Age 12-6 to 13-6. Clinic Cases)

		Method					
		Failure		Trial and Error		Planned	
Grade	Number	Number	%	Number	%	Number	%
I	9	7	77	2	99	0	0
II	4	3	75	1	100	0	0
III	1	1	100	0	100	0	0
IV	8	2	25	5	87	1	12
V	5	1	20	2	60	2	40
VI	3	0	0	1	33	2	66
VII	1	0	0	0	0	1	100
VIII	2	0	0	0	0	2	100
Total	33	14	42	11	33	8	24

A similar table was constructed for each of the ages from 11-6 to 15-6, the years for which the grade of which the child was a member in the school or at which he quit if he did so at the legal limit of fourteen could be most surely ascertained. These tables showed for each age the same large break in the percentages of qualitative reaction to the test at the two year retardation point as has just been shown in the table for the 13-year-olds. The tables were then combined to show the reaction for two year or more retarded cases and those showing less than two years or no retardation. Table XXXII shows the data so arranged.

TABLE XXXII

Test V. Puzzle Box. (11-6 to 15-6, Retarded and Unretarded, Clinic Cases)

		Method					
		Failure		Trial & Error		Planned	
	Number	Number	%	Number	%	Number	%
Retarded 2 yr. or more	115	46	40	57	89	12	10
Unretarded	69	8	11	34	49	27	39

The table shows that of the retarded cases 10 per cent were able to plan the work of this test, and of the unretarded cases 39 per cent were able to plan it; that 40 per cent of the retarded failed and 11 per cent of the unretarded cases failed.

Table XXXIII shows the data obtained for the 12-6 to 13-6 cases for Test IX, Cross Line A.

TABLE XXXIII

Test IX. Cross Line A. (Age 12-6 to 13-6. Clinic Cases)

		Failure		Succeeded: First		Succeeded: Second		Succeeded: Third		Succeeded: Fourth	
Grade	Number	Number	%	Number	%	Number	%	Number	%	Number	%
I	9	7	77	1	11	0	0	0	0	0	0
II	4	2	50	1	25	0	0	0	0	0	0
III	3	2	66	1	33	0	0	0	0	0	0
IV	11	5	45	3	27	1	9	2	18	0	0
V	6	2	33	3	50	0	0	1	16	0	0
VI	2	0	0	2	100	0	0	0	0	0	0
VII	1	0	0	1	100	0	0	0	0	0	0
VIII	2	0	0	2	100	0	0	0	0	0	0
Total	38	18	47	14	36	3	7	3	7	0	0

The table shows that above the fifth grade practically all succeed and that below the fifth grade there is a large percentage of failure.

The data of this test were arranged with reference to retardation as was the test last discussed, showing success and failure. Table XXXIV shows the data so arranged.

TABLE XXXIV

Test IX. Cross Line A. (11-6 to 15-6, Retarded and Unretarded, Clinic Cases)

		Failure		Succeeded	
	Number	Number	%	Number	%
Retarded 2 yr. or more	123	45	36	78	63
Unretarded	79	7	8	72	91

Here it is seen that of the retarded cases 63 per cent succeeded and of the unretarded cases 91 per cent succeeded.

The data for test X, Cross Line B, for the 12-6 to 13-6 year cases is shown in Table XXXV.

TABLE XXXV

Test X. Cross Line B. (Age 12-6 to 13-6. Clinic Cases)

Grade	Number	Failure Number	Failure %	Succeeded First Number	Succeeded First %	Succeeded Second Number	Succeeded Second %	Succeeded Third Number	Succeeded Third %	Succeeded Fourth Number	Succeeded Fourth %
I	9	7	77	1	11	0	0	1	11	0	0
II	4	3	75	0	0	0	0	0	0	1	25
III	3	2	66	0	0	1	33	0	0	0	0
IV	10	6	60	1	10	3	30	0	0	0	0
V	7	1	14	3	42	2	28	1	14	0	0
VI	6	0	0	5	83	0	0	1	16	0	0
VII	1	0	0	1	100	0	0	0	0	0	0
VIII	2	0	0	2	100	0	0	0	0	0	0
Total	42	19	45	12	28	6	14	2	4	1	2

This table also shows the large percentage of success above the fifth grade and the very large percentage of failure below that grade. Table XXXVI shows the data with reference to retarded and unretarded cases.

TABLE XXXVI

Test X. Cross Line B. (11-6 to 15-6, Retarded and Unretarded, Clinic Cases)

	Number	Failure Number	Failure %	Succeeded Number	Succeeded %
Retarded 2 yr. or more	123	52	41	71	57
Unretarded	84	4	4	80	95

This table shows that 57 per cent of the retarded cases and 95 per cent of the unretarded succeeded with this test.

VIII

INDIVIDUAL REACTIONS TO HEALY-FERNALD TESTS

The following seven tables show the individual data of the children of the private school to those tests which involve qualitative types of reaction.

The first column to the left shows the individual number of the child when the data were recorded from the original notes. The next column records age; the third grade, and the following columns the type of reaction to each test.

TABLE XXXVII

Reaction of Kindergarten Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV
157	5 +	Kdg.	Chance, Learning +	Chance, Readjustment —*
158	5 +	"	Tr. and Er., Learning +	Chance, Readjustment +
140	5- 3	"	Tr. and Er., Learning +	Planned, Readjustment +
155	5- 8	"	Chance, Learning +	Chance, Readjustment —*
145	5- 9	"	Planned	Planned, Readjustment +
154	5- 9	"	Chance, Learning +	Planned, Readjustment +
138	5-10	"	Chance, Learning +	Chance, Readjustment +
160	5-10	"	Tr. and Er., Learning +	Planned, Readjustment +
141	5-11	"	Chance, Learning +	Tr. and Er., Readjustment +
159	5-11	"	Chance, Learning +	Chance, Readjustment —*
149	6	"	Chance, Learning +	Tr. and Er., Readjustment +
132	6- 1	"	Chance, Learning +	Chance, Readjustment +
139	6- 1	"	Planned	Planned, Readjustment +
137	6- 2	"	Planned	Tr. and Er., Readjustment +
144	6- 2	"	Tr. and Er., Learning +	Chance, Readjustment +
143	6- 3	"	Tr. and Er., Learning +	Planned, Readjustment +
153	6- 4	"	Chance, Learning +	Planned, Readjustment +
135	6- 5	"	Tr. and Er., Learning +	Chance, Readjustment —*
142	6- 6	"	Chance, Learning +	Planned, Readjustment +
146	6- 6	"	Chance, Learning +	Chance, Readjustment +
152	6- 6	"	Chance, Learning +	Tr. and Er., Readjustment +
134	6-10	"	Planned	Planned, Readjustment +
151	7	"	Chance, Learning +	Chance, Readjustment +
136	7- 4	"	Planned	Planned, Readjustment +
147	7-10	"	Chance, Learning +	Planned, Readjustment +
148	8- 1	"	Chance, Learning +	Tr. and Er., Readjustment +

+ Method for second attempt, Trial and Error.
* Made errors, but method planned.

TABLE XXXVIII

Reaction of First Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X
93	6-6	I	Planned	Planned	Tr. and Er.	1st	1st
39	6-6	"	Chance	Planned	F*	F	F
92	6-6	"	Planned	Chance	Tr. and Er.	1st	3rd
96	6-7	"	Tr. and Er.	Tr. and Er.	F	1st	1st
91	7	"	Chance	Chance	F	F	F
94	7-1	"	Planned	Planned	F	1st	F
127	7-1	"	Chance	Planned	F	3rd	3rd
86	7-2	"	Chance	Chance	Tr. and Er.	1st	1st
129	7-4	"	Chance	Tr. and Er.	F	1st	1st
98	7-5	"	Chance	Chance	Tr. and Er.	1st	F
88	7-5	"	Planned	Chance	Tr. and Er.	1st	4th
128	7-5	"	Chance	Tr. and Er.	F	3rd	1st
90	7-7	"	Tr. and Er.	Chance	F	1st	F
87	7-10	"	Chance	Chance	F	1st	1st
97	8	"	Chance	Chance	Tr. and Er.	1st	2nd
95	8	"	Tr. and Er.	Chance	Tr. and Er.	1st	1st
131	8	"	Tr. and Er.	Planned	Tr. and Er.	4th	F
125	8	"	Chance	Tr. and Er.	F	4th	2nd
126	8-2	"	Chance	Planned	F	1st	1st
89	8-6	"	Planned	Chance	Tr. and Er.	1st	1st

*F = Failure

TABLE XXXIX

Reaction of Second Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X	Test XI
32	7-6	II	Tr. and Er.	Chance	F	1st	1st	Idea —
36	7-7	"	Chance	Chance	Tr. and Er.	1st	1st	Idea —
29	7-8	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea —
37	7-8	"	Planned	Planned	Tr. and Er.	1st	1st	Idea —
38	7-8	"	Tr. and Er.	Planned	Tr. and Er.	F	F	——
27	7-9	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea —
33	7-9	"	Tr. and Er.	Planned	Tr. and Er.	1st	F	——
30	7-10	"	Planned	Chance	F	1st	1st	Idea +
34	7-10	"	Planned	Planned	Tr. and Er.	1st	2nd	Idea +
31	7-11	"	Chance	Planned	Tr. and Er.	1st	1st	Idea —
35	8	"	Planned	Planned	Tr. and Er.	1st	2nd	Idea —
28	8-2	"	Chance	Planned	Tr. and Er.	2nd	1st	Idea —
23	8-7	"	Planned	Planned	Tr. and Er.	1st	1st	Idea —
25	8-8	"	Planned	Planned	Tr. and Er.	F	4th	Idea +
24	8-9	"	Planned	Planned	Tr. and Er.	1st	1st	Idea —
26	8-10	"	Planned	Chance	Planned	1st	4th	Idea —
22	9-3	"	Planned	Tr. and Er.	Tr. and Er.	1st	4th	Idea —

TABLE XL

Reaction of Third Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X	Test XI
20	8	III	Chance	Planned	Tr. and Er.	1st	1st	Idea —
21	8-2	"	Planned	Chance	Tr. and Er.	1st	2nd	Idea +
6	8-8	"	Planned	Planned	Tr. and Er.	4th	1st	Idea —
12	8-9	"	Tr. and Er.	Chance	Tr. and Er.	1st	1st	Idea +
10	8-10	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea —
2	9	"	Planned	Chance	F	1st	1st	Idea —
3	9	"	Planned	Planned	F	1st	1st	?
13	9-2	"	Chance	Chance	Tr. and Er.	1st	1st	Idea +
5	9-2	"	Planned	Planned	F	1st	1st	Idea —
7	9-2	"	Chance	Chance	Tr. and Er.	1st	1st	?
8	9-2	"	Planned	Planned	Planned	1st	1st	Idea —
1	9-3	"	Planned	Chance	Tr. and Er.	1st	1st	Idea +
11	9-4	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +
4	9-4	"	Planned	Planned	Planned	1st	1st	Idea +
9	9-4	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +
17	9-9	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
16	9-9	"	Planned	Chance	Tr. and Er.	1st	1st	Idea +
18	9-11	"	Chance	Tr. and Er.	Tr. and Er.	1st	3rd	Idea —
14	10-2	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
15	10-4	"	Tr. and Er.	Planned	Tr. and Er.	1st	3rd	Idea —
19	10-4	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +

TABLE XLI

Reaction of Fourth Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X	Test XI
41	9	IV	Planned	Planned	Tr. and Er.	1st	1st	Idea +
42	9-4	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +
43	9-4	"	Tr. and Er.	Planned	Tr. and Er.	4th	1st	Idea +
40	9-5	"	Planned	Planned	Tr. and Er.	1st	3rd	Idea —
56	9-9	"	Planned	Planned	F	1st	1st	Idea +
53	9-9	"	Planned	Planned	Planned	1st	1st	Idea +
47	9-9	"	Tr. and Er.	Planned	Planned	1st	1st	Idea —
51	9-10	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
48	9-10	"	Planned	Tr. and Er.	Planned	1st	1st	Idea —
45	10	"	Tr. and Er.	Planned	F	1st	4th	Idea —
50	10-1	"	Planned	Planned	Planned	1st	1st	Idea +
55	10-2	"	Tr. and Er.	Planned	Tr. and Er.	4th	3rd	Idea +
52	10-2	"	Tr. and Er.	Chance	Tr. and Er.	1st	1st	Idea +
46	10-4	"	Planned	Chance	Tr. and Er.	1st	4th	Idea —
49	10-4	"	Planned	Planned	Tr. and Er.	1st	1st	Idea —
54	10-5	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
57	10-5	"	Planned	Planned	Tr. and Er.	1st	1st	?
44	10-5	"	Planned	Planned	Tr. and Er.	1st	1st	Idea —
61	10-8	"	Planned	Planned	Tr. and Er.	2nd	4th	Idea —
59	10-9	"	Planned	Planned	Tr. and Er.	4th	3rd	Idea +
60	10-9	"	Planned	Planned	Planned	1st	1st	Idea +
58	11-2	"	Planned	Planned	Planned	1st	1st	Idea —
63	11-6	"	Planned	Planned	Planned	1st	1st	Idea +
62	12-2	"	Planned	Chance	Tr. and Er.	1st	1st	Idea +

TABLE XLII

Reaction of Fifth Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X	Test XI
66	10-3	V	Planned	Chance	Planned	1st	1st	Idea +
65	10-3	"	Planned	Tr. and Er.	Tr. and Er.	1st	1st	Idea +
64	10-5	"	Planned	Planned	Planned	1st	1st	Idea —
67	10-6	"	Planned	Planned	Planned	1st	1st	Idea —
69	10-6	"	Planned	Planned	Planned	1st	1st	Idea +
72	11	"	Planned	Planned	Planned	1st	1st	Idea +
71	11-2	"	Planned	Planned	Planned	1st	1st	Idea +
73	11-2	"	Chance	Planned	Tr. and Er.	1st	2nd	Idea —
68	11-5	"	Planned	Planned	Planned	1st	1st	Idea +
70	11-5	"	Chance	Planned	Planned	1st	1st	Idea +
74	11-6	"	Chance	Planned	Tr. and Er.	1st	2nd	Idea +
78	11-6	"	Planned	Chance	Tr. and Er.	1st	1st	Idea +
79	11-8	"	Planned	Planned	Planned	1st	1st	Idea +
77	12	"	Planned	Tr. and Er.	Planned	1st	1st	Idea +
76	12-1	"	Chance	Planned	Tr. and Er.	1st	2nd	Idea —
75	12-2	"	Planned	Planned	Planned	1st	1st	?
83	12-6	"	Planned	Chance	Tr. and Er.	1st	1st	Idea +
80	12-7	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea —
82	12-7	"	Planned	Tr. and Er.	Tr. and Er.	1st	3rd	Idea +
84	12-11	"	Chance	Chance	Planned	1st	1st	Idea —
81	12-11	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
85	13-8	"	Planned	Planned	Planned	1st	1st	Idea +

TABLE XLIII

Reaction of Sixth Grade Children to Healy-Fernald Tests

No.	Age	Grade	Test III	Test IV	Test V	Test IX	Test X	Test XI
115	12	VI	Planned	Planned	Planned	1st	1st	Idea —
116	12	"	Planned	Planned	Planned	1st	1st	Idea +
124	12	"	Planned	Planned	Planned	1st	1st	Idea +
105	12-1	"	Chance	Tr. and Er.	Planned	1st	1st	Idea —
109	12-1	"	Planned	Planned	Planned	1st	1st	Idea +
104	12-1	"	Planned	Planned	Planned	1st	1st	Idea —
123	12-1	"	Planned	Planned	Planned	1st	1st	Idea +
111	12-2	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +
100	12-2	"	Planned	Tr. and Er.	Planned	1st	1st	Idea —
114	12-3	"	Planned	Planned	Tr. and Er.	1st	1st	Idea +
102	12-6	"	Tr. and Er.	Planned	Planned	1st	1st	Idea —
106	12-6	"	Planned	Planned	Planned	1st	1st	Idea +
119	12-8	"	Planned	Tr. and Er.	Planned	1st	1st	Idea —
118	12-8	"	Tr. and Er.	Chance	Tr. and Er.	1st	1st	Idea +
113	12-8	"	Chance	Planned	Planned	1st	1st	?
108	12-9	"	Planned	Planned	Planned	1st	1st	Idea —
103	12-9	"	Planned	Planned	Planned	1st	1st	Idea —
120	12-11	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea —
99	13	"	Planned	Planned	———	1st	1st	Idea —
122	13	"	Planned	Planned	Planned	1st	1st	Idea +
121	13	"	Tr. and Er.	Planned	Tr. and Er.	1st	1st	Idea +
117	13-4	"	Tr. and Er.	Chance	Tr. and Er.	1st	1st	Idea —
110	13-5	"	Planned	Planned	Planned	1st	1st	Idea +
107	14-2	"	Planned	Tr. and Er.	Tr. and Er.	1st	1st	Idea +

IX

SUMMARY OF STANDARDIZATION OF HEALY-FERNALD TESTS

From the tables and discussions above may be summarized the reaction to be expected of children of different ages to each test.

Test I. Introductory Puzzle.—Accomplished by children of kindergarten age or experience. Eighty-nine per cent make less than five errors in performing the test exclusive of the triangle. Triangle constitutes a learning test.

Test II. Special Picture Puzzle.—At the age of 9-6 to 10-6 accomplished by 75 per cent with not more than two errors.

Test III. Construction Puzzle A.—At the age of 10-6, 90 per cent do the test by the planned method. Under the age of 8-6 is done by a large percentage by chance. Constitutes a learning test for children of kindergarten age.

Test IV. Construction Puzzle B.—At the age of 8-6 to 9-6, 65 per cent of the children do the test by the planned method. Constitutes a learning test and a test of readjustment of an already learned content to fit an altered situation for children of kindergarten age.

Test V. Puzzle Box.—At the age of 10-6 to 11-6 the test is performed by the planned method by 72 per cent of the children tested.

Test IX. Cross Line Test A.—Performed by 75 per cent of children of first grade experience (so graded because of necessity of accomplishment of writing numbers)—with not more than two trials.

Test X. Cross Line Test B.—Performed by 69 per cent of children of second grade with not more than two trials. Performed by 65 per cent of children of first grade with not more than three trials.

Test XI. Code Test.—The reasoning step is performed by

60 per cent of children of fourth grade. At the fourth grade and above the average error is not more than four out of the possible eleven.

Test XV. Opposite Test.—Performed by 62 per cent of children between 6-6 and 7-6 with not more than two errors out of a possible twenty.

Test XII. Memory for Visual Verbal Presentation.—Sixty-one per cent of children of third grade recall not less than fifteen items of the twenty. Is not suitable for children under second grade because of necessity of reading accomplishment.

Test XIII. Memory from Auditory Verbal Presentation.—Eighty-four per cent of first grade children recall not less than nine items of the twelve.

Test VIII. Learning Test, Arbitrary Associations.—Performed by 55 per cent of children of first grade with no error, and by 45 per cent with average of two errors; by 70 per cent of second grade children with no errors.

The above summary may be arranged with reference to grade. After each test in the summary below is indicated the reaction to be expected of the children of the grade under which the test is listed. The type of reaction shown by approximately 75 per cent of the children of the grade is indicated as the one to be expected of the grade. In case this percentage is distributed over two or more types of reaction these types are indicated with the one which is preferable mentioned first. Where a test has reached a maximum in one grade or which shows little variation for several grades it is not repeated in the summary for the higher grades.

Kindergarten

Test I. Errors with paired pieces. Triangle by trial and error, learning test.

Test II. Accomplish (in contrast with defectives of same age) with much trial and error.

Test III. Trial and error or chance, learning test.

Test IV. Trial and error or chance, learning test.

Grade I

Test I. Less than three errors. Triangle by trial and error.
Test II. Errors of paired pieces.
Test III. Trial and error or chance.
Test IV. Trial and error or chance.
Test V. Failure.
Test IX. Succeed with second trial.
Test X. Succeed first to fourth trial.
Test XV. Succeed (in contrast with defectives) with less than four errors.
Test XIII. Recall nine or more items.
Test VIII. Two errors of memory.

Grade II

Test I. Triangle, trial and error or planned.
Test III. Trial and error or planned.
Test IV. Planned or trial and error.
Test V. Trial and error.
Test IX. Succeed first trial.
Test X. Succeed first to third trial.
Test XI. Idea—, eight errors.
Test XV. Less than three errors.
Test XII. Twelve or more items. (In the column, *14 or less.*)

Table XXVIII, p. 117, are included three children who remembered less than twelve items.)
Test XIII. Nine or more items.

Grade III

Test III. Planned or trial and error.
Test IV. Planned or trial and error.
Test V. Trial and error.
Test IX. Succeed first trial.
Test X. Succeed first trial.
Test XI. Idea + or —, seven errors.
Test XV. Three or less errors.

Grade IV

Test III. Planned.
Test IV. Planned.
Test V. Trial and error.
Test XI. Idea +, four errors.

Grade V

Test V. Planned or trial and error.
Test XI. Idea +, two errors.

X

SCHOOL SUBJECTS AS MATERIAL FOR TESTS OF MENTAL ABILITY

In several large cities the school child, because of his unfavorable reactions to the school situation, comes in for clinical diagnosis of mental and physical condition. Since it is the child's reaction to the school situation which is at fault, it is well to test him along the line of the special abilities which he is expected to develop under the conditions of the school situation. The school subjects may be made to form a series of tests which can be used from year to year to measure or check up the development of special abilities. The curriculum of the school forms a serial arrangement of accomplishments proceeding from the simplest subject-matter of the first grade to the complexities of the eighth grade. Such an arrangement of tests derived from the school subjects, as forms a psychological serial arrangement from that which is simplest to that which is complex may be derived from the curriculum as it exists. The following series of tests and suggestions for the evaluation of the child's development with reference to the school curriculum has resulted from an examination of several hundred children considered by the school to be unfavorable in their reaction to the school situation, and a comparison of them with children considered normal with regard to their reaction to the school situation. The subjects chosen for this series of tests are those of reading, writing and arithmetic.

Reading.—The most important accomplishment in the school life is that of reading. The child's progress throughout the school is dependent entirely upon his attaining it. Upon it depends his progress to a large extent in arithmetic and almost entirely in history and geography and other such subjects which consist of classified or organized groups of facts. The accomplishment of the child in this subject may be arranged with

reference to *quantity and quality.* A defective child may be deficient in one or both of these two characteristics of the reading accomplishment. He may be incapable of learning to recognize the words of the printed page; he may show himself capable of learning words only very slowly or of forgetting them quickly and easily; he may show himself capable of learning words with some facility in memorizing them, and so of becoming a good reader, but incapable of gaining ideas from the words which he reads. It is this latter characteristic which one is to understand as included in its various aspects under the term "quality."

The child may show an ability to recognize words from the printed page to a greater or less extent, but this recognition with the defective child consists largely, merely of a mechanical type of visual memory which serves as stimulus for its associated vocal prototype. The child who learns words in this way only is always dependent upon his teacher, since he can acquire for himself no new or unfamiliar word from the printed page. He can become somewhat independent of his teacher only if he learns phonetic values. Defective children are sometimes capable of acquiring very large visual vocabularies but show themselves quite deficient in perceiving phonetic relationships. Children of the first grade may be expected to acquire the simplest phonetic elements of the English language.* The child who can obtain a visual vocabulary with facility, who gains a perception of the simple phoentic values, and who learns to combine them correctly for the independent learning of new words is considered a favorable reactor so far as the subject of reading of the first grade is concerned in the public schools. The various steps from the early period of the reading accomplishment to its complex fulfillment are indicated as follows:

I. Quantity

1. *Knows no words.*—This is the condition of the average child when he enters school at six or seven years of age, and is one persisted in by the low type of defective

* Cf. Chicago Public Schools, Course of Study for the Elementary Schools, 1912.

child for several years or longer. This low type of defective child shows himself incapable of perceiving the fine differences which serve to distinguish one word from another on the printed page, though he is able to use spoken language. Some knowledge of the degree of his defectiveness may be gained when one knows the length of time in which he has persisted in this disability.

2. *Can recognize a few unrelated words.*—This is the accomplishment of the average normal child after a few days spent in the school. It is a *condition* persisted in by many defective children sometimes for years. In such case, the defective child has learned a word here and a word there which have stuck in his memory, and he recognizes them wherever he sees them. He shows himself, however, incapable of gaining sufficient words to make his reading a consecutive process with regard to meaning. The words which he does learn bear, perhaps, no relation to the amount or type of teaching that has been given. The learning of them is largely a matter of chance, and just why certain words have been learned and many others imparted at the same time in his instruction have been forgotten cannot be determined.

3. *Can read entire sentence in the first or some other reader.*—This step in its simplest form is attained by the child after a few weeks in school. The reader which he has in school,—if because of being a defective he is placed in an ungraded room,—compared with the number of years that the child has been in school is some measure of his defectiveness in learning to read.

4. *Can read at sight any material such as newspapers,* etc.—This is the highest grade which may be attained in the ability to read, with reference to quantity. It is attained by the normal child with the fifth grade.

The phonetics which underlie the reading process is the great stumbling block of the defective child. Seldom is one found who has this accomplishment. He may be able to learn a very few of the simplest combinations, such as consist of one or two consonants and a vowel. The normal child progresses in his

knowledge of phonetic values, to such an extent that he becomes independent of the teacher in so far as the illogical complexities of our English spelling permit. At the fourth grade the normal child is able to work out new and unfamiliar words with approximate phonetic correctness.

II. Quality

1. *Mechanical.*—The defective child may be able to accomplish with reference to quantity in reading anything between the limits set above from the lowest to the highest stage of accomplishment. However great his accomplishment in the quantity of his reading he is unable to read a new passage other than mechanically, that is all he can do is, to use a familiar popular phrase, parrot-like. This type of reading may be described as a straight line association between the visual and the vocal centers. The child makes no, or few, other associations with the ideas gained from the printed page before him. The words or ideas which he reads do not relate themselves in his mind with anything else he has read or with other experiences he has had, such that a complex of related ideas are formed in his mind which he can reproduce orally or otherwise. He can reproduce few, if any, of the ideas which the page contains. Upon being asked what he has read about, he remains dumb or answers merely with a word or phrase contained in what he has read. This type of reading may be suspected from the monotonous tone with which it is delivered. An extreme example of this was that of a girl of eleven, found in the second grade. She had attained the fourth step in quantity, and was very proficient in her rendering of phonetic values. She read a long paragraph, of which the following is the beginning sentence: *"It was in the spring of the year 1826 about ten o'clock, when Mr. Amos Bliss, manager and one of the proprietors of the Northern Spectator, was in the garden, behind his house planting potatoes,"* etc. This selection was taken from a Fifth Reader which she had never seen. She pondered over the unfamiliar words *spectator, manager, proprietors,* and pronounced them correctly, with very little loss

of time. The other words in the selection were read with little or no hesitation. Upon being asked what she had read about, she made no reply; and when the question was repeated she finally said, "It was about a horse." The selection contained no reference to a horse, but the opposite page contained a picture of one. The normal child, when reading material which is not familiar to him must give much attention to spelling and deciphering unfamiliar words, he will often because of this distraction, be unable to give the sense of the selection read. A judgment of the quality of the child's reading should, therefore, in every case be deduced only from material which he reads with reasonable facility and which contains few if any unfamiliar words.

2. *Appreciative.*—This type of reading is the opposite of the mechanical type just discussed. With this type there is usually expression of tone in reading which shows the child's understanding or appreciation of the selection read. Upon being questioned, he can tell in a sentence or more, the essential elements of the selection. It is usually a sure sign that the reading has been appreciative if pleasure is shown. However, expression is not an infallible test. Defective children may be trained to read selections with expression, and if the circumstances of the training have been pleasant the child may incorporate these pleasant associations into the reading process itself, so that he seems to be enjoying the ideas derived from the selection. In such a case, however, he fails to read with expression or to reproduce the sense of the meaning when the same material is arranged in unfamiliar form.

3. *Apperceptive.*—This is a grade of performance above the *appreciative,* in that there is a relating of what is read to a larger complex of knowledge or experience in addition to the reproducing of content. In this type of reading the child can reproduce orally without further prompting the essential details and can give an interpretation of a selection. Fables lend themselves readily to such an interpretive test. Defective children often can answer correctly any questions asked about a selection read, but are unable to organize it for themselves and are unable

to give an interpretation of its meaning when the material is of a literary type other than that of didactic narrative.

4. *Initiative.*—Reads voluntarily. Many children who attain the highest stage as relates to quantity in reading may at the same time really be able to gain so little from such abstractly represented ideas that they never voluntarily read for their own pleasure. Many children who have not yet gained the highest stage as relates to quantity still read voluntarily because of a desire to gain knowledge or to meet certain social demands. It is seldom that a defective child reads from any other motive than to please his teacher.

Results of Reading Tests for Normal and Defective Children

Two selections to test ability in reading were given to seventeen children of each grade from the first to the sixth, chosen from five public schools of Chicago. Three from each grade were chosen from four schools and five from another. These schools were situated in foreign speaking districts. Of the eighty-five children tested, thirty-eight came from homes which were counted as English speaking, since the mother was able to speak English. In the remaining forty-seven homes, according to the testimony of the children and the teachers who knew them, the mothers could not speak English.

The teachers were given the following directions for choosing the children for the test: *Select children who are average good readers for the grade; do not select the very best reader you have. Select them from that age of which you have the most; that is, if you have more nine-year-old children than any other age select nine-year-old ones.* The first grade teachers were asked to select only those who had begun school in September. The teachers consulted the record of ages upon entrance in September. The tests were given during six weeks of May and June. The children of the first grade were, then, near the seventh birthday; the second grade were near the eighth; the third grade were near the ninth; the fourth grade were near the tenth; and the fifth grade were near the eleventh.

The defective children who were given the tests at the same time and in the same way were between the ages of ten and sixteen who had been in the special rooms for defective children for at least one year. Many of them had been in these rooms for several years. With one exception the rooms were situated in the same schools in which the normal children were tested. There were five such rooms; forty-six children of the eighty who constituted the membership of these rooms fell within the conditions chosen. None of them had uncorrected defects of sight or hearing.

The first of the selections chosen was the story of *The Fox and the Grapes.*

THE FOX AND THE GRAPES

One day a fox went down the road.

"How hungry I am!" he said. "I wish I could find something to eat."

Just then he saw a grapevine. It had ripe grapes on it.

"Oh, how good those grapes look! I will have some," said the fox.

But he could not reach the grapes. They were too high on the vine.

He jumped high up in the air, but he could not get them.

At last he went away hungry.

The birds heard him say, "Those old grapes are sour.

They are not good for a fine fox like me."

But the birds knew better.

This selection was made in order to give each child something to read that he had been taught in school. The story is one of the lessons of the first reader taught toward the end of the first year. All but the first group of first grade children tested had read it. The general practice of the school with such stories as this is to read, recount, and discuss, and in some instances dramatize the story. If the children had not all had an opportunity to recount the story individually they had heard some of their classmates do so and had joined in the discussion of it. All the defective children had had opportunity

to hear it and read it and doubtless to recount it several times, since much attention is given to such work with the defective children. Each child had spent at least two years in the first garde before entering the special room.

The defective children were all mentally at least seven years of age according to the Binet scale. With the exception of the stamp counting test with which three failed, all could pass all the tests for seven years of age. All could do the Thorndike *a* test with no more than three errors. All could do the Healy-Fernald Test I as well as the average of the first grade. With tests of greater complexity there was much variation.

The data recorded include time for reading the selection, errors of pronunciation, verbatim reproduction of the story, and the correctness or falseness of the interpretation of the motive of the fox in saying the grapes are sour. This last item was obtained by asking after the child had given his reproduction of the story, "Were the grapes sour?" If the answer was, "No," then, "Why did he say so?" The interpretation was considered correct when the child indicated that the fox was disgruntled at not being able to get the grapes. The idea was not always expressed in words, but some times in an inflection of the voice in the answer, "Just because he couldn't get them." If the answer to the first question was, "Yes," then, "How did he know?" To this question there was sometimes an attempt to make an explanation such as that of one child, "He looked at them," but generally there was silence.

The reproduction was classed under the following heads, *scant, adequate,* and *full.* That reproduction was classed as *scant* which did not contain a sufficient number of the essential details to tell the story, or which had them so mixed or otherwise wrong that the story was not correctly rendered. An *adequate* reproduction contained enough details to indicate the story, but with little or none of the embellishing details of dramatic setting. The *full* reproduction contained all or nearly all the items of the original story.

The two following reproductions were classed *scant.*

"The fox couldn't reach the grapes, he went away hungry, the birds knew better."

"The fox was hungry, he wanted something to eat, so the birds said them grapes are not good, they are sour."

It should be remarked here that no reproduction was classed scant if the child could answer a series of questions which would bring out his understanding of the story, such as, "What did he try to get? What did he say?" etc.

The following is one of the poorest in the matter of detail of the reproductions classed as *adequate:*

"About the fox, he was hungry, and he wanted some grapes to eat, they were too high and he could not get them and he said those grapes are sour."

The following is a *full* reproduction:

"One day the fox went down the road, he was very hungry, he said I wish I had something to eat, then he saw a grape vine, it had ripe grapes on it, how nice it looked, I will get some, but he could not get any, then he went away hungry, the birds heard him say, those grapes are sour, those grapes are not good for a fox, but the birds knew better."

In recording mispronunciations those words which the child could not decipher in ten seconds were classed with the mispronounced. Words mispronounced in reading such as *then* for *they* were called to the child's attention with the question, "Is it *then?*" If he then pronounced it correctly the word was not classed with the mispronunciations. The time record for normal children includes time taken up in this way. For the defective children a time record was seldom of any significance because of the many corrections and helps necessary to get the child through the selection.

The first grade children of the first school tested varied so widely from the other first grade groups that their record could not be included in the averages. Their performance supported the assertion of the principal that this particular group of foreigners were very slow in learning to read. It is possible that their record would have been nearer the average if they had been tested last. The same backwardness in reading was

exhibited somewhat by the second grade of that school but not sufficiently to make necessary their elimination from the averages. The third grade showed no variation.

Table XLIV shows the data gained from Selection I.

TABLE XLIV

Data of Reading Test I

Grade	Number of children	Average time	Average number errors	Reproduction: Scant	Reproduction: Adequate	Reproduction: Full	Interpretation: +	Interpretation: —
I	12	82″	.5	3	9	0	6	6
II	17	62″	0	0	9	8	6	11
III	17	48″	0	0	4	13	13	4
IV	17	48″	0	0	5	12	15	2

The time average for the first grade of the above table had a range as follows: two took between two and three minutes to read the selection; six between one and two minutes; three less than one minute. The error average was made up of one child's five errors and two other errors made by two children.

The time average for the second grade ranged; one between two and three minutes, four between one and two minutes, seven less than one minute. There was little variation in the time of the third and fourth grades.

It is rather significant of the small child's ability to understand the point of the fable type of story that though all these children had been taught this story and had discussed it more or less, it is at the third grade that it is understood. The children of the first and second grades who gave a correct interpretation probably only reproduced their teaching.

The errors in pronunciation made by the normal children in this and the second reading test was always in favor of a word which had considerable visual or phonetic resemblance to the correct word. The errors made by the defective children with the first selection which was perfectly familiar to them in content, at least, were absurd so far as visual or phonetic values were concerned, but were calculated to fill in the context. The defective child reads, for instance, that the fox saw a vine with *berries on it*. Because of the great prevalence of this type of variation the performance of the defective group can

not be compared with that of the normal. Another type of comparison will be made below.

The second selection was chosen because of its unfamiliarity, of its wide range of verbal difficulty, and simplicity of content, which at the same time possessed a definite unity. It was taken from page 177 of Jones' Fifth Reader. This reader is not in use in the schools, and probably had never been seen by any of the children who read the selection. Since the verbal expression is rather complex and the words used are not those of the ordinary child's every day vocabulary it was desirable to keep the content matter simple, that not too many difficulties would confront the child at the same time. The paragraph selected was: *It was a fine spring morning in the year 1826 about ten o'clock, when Mr. Amos Bliss, the manager and one of the proprietors of the Northern Spectator, might have been seen in the garden behind his house planting potatoes. He heard the gate open behind him, and, without turning or looking round, became dimly conscious of the presence of a boy. But the boys of country villages go into whosoever garden their wandering fancy impels them, and supposing this boy to be one of his own neighbors, Mr. Bliss continued his work and quickly forgot that he was not alone.*

The same data as for the first test were recorded, except that there is no interpretation for this one.

Following is an example of a reproduction classed as *adequate:*

"A man was planting potatoes in his back yard and a boy came in and he thought it was one of his neighbor boys and he didn't pay attention to him and forgot he wasn't alone."

The following reproduction was classed as *full.* "Mr. Bliss was planting potatoes behind his house, he looked up suddenly and there was a boy coming in his yard, but in that country the boys go wherever their fancy impels them and he thought it was one of his neighbors and kept on with his work and after a while he forgot that he was not alone."

No child grasped the significance of the title, *manager and one of the proprietors of the Northern Spectator.*

Table XLV shows the data of the second selection.

TABLE XLV
Data for Reading Test II

Grade	Number	Average time	Average number errors	Reproduction Scant	Adequate	Full
II	17	194″	7.8	14	3	0
III	17	91″	2.8	13	4	0
IV	17	74″	1.0	6	7	4
V	17	54″	.5	0	9	8

The words most frequently mispronounced were, *manager proprietors, Northern, Spectator, conscious, whosoever, impels, continued.* The mistakes of the normal children consist, for the most part, of misplaced accent, the omission of an obscure syllable in long words, or giving a different phonetic value than is the right one for the word in which the letter is found. Thus *manager* becomes *managēr; proprietors* becomes *prop′rietors,* or *propetors,* etc.

Results of Reading Tests for Defective Children

The reading of the defective children presents such irregular characteristics that averages which would present any meaning are difficult to obtain. The children tested had been much drilled in the story of the fox and the grapes. Nevertheless twenty-four of the forty-six could read it with less facility than the first grade children. They made many errors of the absurd type discussed above. Their reading consisted of some unerring recognition of words and more or less filling in to supply a remembered context. Nine of the defectives could give only a scant account of the story and an incorrect interpretation.

Twelve defective children were graded as equal to the first grade child in reading ability. Ten were graded equal to the second grade child in ability as regards the mechanical and qualitative aspects of the second reading test. Two of the defectives of the second grade could give an adequate account of the matter read. One of these children was ten years of age and by reason of this test and others was reclassified on his record sheet as only backward and returned to the regular

grades of the school. The other, twelve years of age, was so deficient in other tests that he was retained in the special room.

Table XLV shows that it is only with the fourth grade that such mechanical skill in reading has been attained as to admit of sufficient attention to content to enable the child to give an adequate reproduction of an unfamiliar selection. With the fifth grade such skill has become general.

Writing

The process of writing, when carried along with the accomplishment of reading, constitutes an added complexity in gaining the symbols of language.

1. *Can form no letters.*—This disability may be due to one or both of two things. The child may be unable to analyze and conceive so complex a thing as a written letter of the alphabet, or the motor control may be so poor as not to permit him to form letters in the usual way.

2. *Copies words or sentences legibly.*

3. *Writes simple sentences from dictation.*—Many children who are proficient in the second stage of the writing process cannot write simple sentences from dictation for several reasons. One is that the child's memory span is so short that he cannot remember even a short sentence until by repetition it has become very familiar to him. In this case he writes the first or second word and then must stop because he cannot remember the remainder. Another reason is that he may be unable to remember the formation of the letters, so that even though his memory may be of the type which can compass a sentence it lacks the ability to remember the symbols for recording it. A third reason, often found, is the child's inability to learn to spell. Though he may be able to remember the sentence and to write from memory all the letters of the alphabet he fails bcause he cannot remember the spelling which has been taught him, and he has no phonetic ability to enable him to proceed independently.

4. *Originates sentences to write.*—Many defective children who are unable to talk or discuss the subjects of their experi-

ence with originality, cannot put over into written form any sentence not dictated to them.

5. *Can write a letter or composition.*—This stage, of course, tests much more than the mere ability to write. As indicated in four, many defective children can relate verbally as much as a letter or composition would contain, and have mastered the mechanics of writing, but they cannot combine the two operations. This is a test of the ability to make use of this tool for the practical purposes of social life.

Arithmetic

The simplest mathematical processes are the result of generalized abstractions. With arithmetical processes there is the necessity for the use of symbols to express such generalizations. These symbols do not stand in one to one relationship with a particular object or experience. The symbols of reading and writing bear such a relationship to the things they represent. The symbols of arithmetic are the expression of a conception. The symbols for the counting series, for instance, cannot relate to a particular thing or experience, but to particularized aspects of that abstract quality of universal relationships which we denominate as number. The simplest process relating to the number relationship is that of counting. It is the first accomplishment of the child in acquiring number ideas.

1. *Counts* (a) As a verbal series merely. Frequently the very young child learns the counting series before he learns that this series may be related to a series of objects. Many defective children who have been in the school for some period of time know the counting series but fail to relate it to a series of objects. When asked to count a row of like objects, such a child repeats, "1, 2, 3," etc., and touches the objects in some other order than that of the counting series.

(b) Counts objects such as lines, beads, etc., serially arranged. This is the second step in the learning of the counting process.

2. *Can make addition and subtraction combinations.*—Many defective children can count objects, but this is as far as their arithmetical accomplishment goes. They cannot represent an

arithmetical situation such as, "If you have two pennies and I give you two more, then how many will you have?" Normal children of the age found in the first grade, from six to seven years, are able to represent such a situation and to make the combination correctly, though the attempt is not made to teach them the process formally. [Chicago]

(a) With objects. The young child who has learned to count and who has not yet had sufficient experience with number relationships to have made their combinations automatic in his memory learns to make a concrete representation of the situation for himself. If you ask him how much is five and four, he can represent the situation with lines or by counting his fingers or some other such device. Many defective children never get beyond this stage in making number combinations. They learn very few combinations, to such an extent as to make them automatic. On the other hand, many defective children learn number combinations as a mere mechanical memory process. If you ask such a child how much is five and four, he answers quickly. However, upon being asked a combination which has not become automatic with him he is quite mute and has no way of solving his problem.

(b) Can make combinations only if put in the form of concrete ideas, such as, "If you have three pennies and I give you two more, how many will you have then?" Many defective children will remain mute if you ask how much is three and two, but if you put it in some such form as this they can represent the situation to themselves and answer correctly. It is perhaps needless to say that this type of defective child never can learn very many mathematical combinations, since he must always depend upon the imagery of concrete experience to carry him through the process. With the normal child of the first grade this process is at first necessary, but he soon becomes able to cast aside this cumbersome method for (c).

(c) Can make combinations with symbols, either written or oral, unaided by objects or the imagery of (b).

(d) Can do problems involving the processes of (1) "carrying" and (2) "borrowing." Many defective children who can

add a long column cannot, however, accomplish the added complexity of "carrying" when adding numbers of more than two columns. Many who can accomplish this feat can not go on and accomplish the still more complex process of "borrowing" in subtraction.

3. Multiplication tables.

(a) Knows the table as a series merely. With this type of accomplishment the child learns to repeat the table, but if items are taken out of their order in the table he is unable to answer unless he again begins at the beginning and repeats the table up to the desired item. His learning in this case is one of mechanical memory of the type presented by the learning of nonsense syllables.

(b) In the early stages of learning the multiplication table, before the combinations have become automatic, the normal child shows his appreciation of the mathematical meaning involved by counting from the last familiar item of the table to gain the next unfamiliar one. The defective child who is not adept at mechanical learning learns to use this method and then continues with it indefinitely.

(c) Knows the table with the items taken at random.

4. Can do the processes of (a) multiplication, (b) short division, (c) long division.

5. *Fractions.*—The work with fractions as it is given in the fifth grade [Chicago] is dependent upon complex processes which can be represented by symbols only. All the arithmetical processes previous to stage four are of such simplicity as to be capable of concrete representation step by step. The processes of addition, subtraction, multiplication and division may be learned as mere mechanical processes which may have no relation in the child's mind either to concrete situations, or to concrete situations symbolically represented. Many defective children learn so complex a process as long division but never can apply it to the working out of concrete problems. It is to them merely a mechanical process and may indicate only an ability to learn a process of such complexity. The work with fractions comprises a set of processes of such great com-

plexity that it is hardly possible to learn them in the mechanical way that long division can be learned. It employs a symbolism of which each individual item represents a complex concrete situation. For instance, to be able to understand such a term as *two-thirds* one must have gone through the concrete process of dividing up the unit, and so on to the final comprehending of this whole process in the symbol, 2/3. One cannot, however, in the simplest type of problem employing the use of fractions, carry on the concrete imagery as he can with the simple number processes discussed above. The various sets of concrete situations represented by the problem, ½ plus ⅜, cannot be kept in mind to aid in determining the result. One must carry on the process with a series of symbolically represented relationships in which each symbol comprises the summing up of a complex situation. The further work of school arithmetic, such as percentage, etc., is only an application of the number processes and relationships learned up to this point.

6. *Practical problems.*—Many defective children can learn number combinations and processes up to the stage of fractions but are unable to apply these processes to the solution of the practical problems of every day life. The simplest of such problems are:

(a.) One-step problems, such as, "If one pencil costs two cents, what will three pencils cost?" Many defective children who can solve a problem of this grade of complexity cannot reverse the process when it is put, "If three pencils cost six cents what will be the cost of one pencil?" Many who can accomplish this feat cannot go further and represent to themselves and solve the problem, "If five pencils cost ten cents what will three pencils cost?" The control of attention, necessary from the beginning to the end of the problem, and the passing over from one step to another to the final third step and the result is too much for them.

(b.) Make change.—Many defective children can learn to make change only in so far as the conditions of their lives have given them experience. They may be able to make change with a dime or a quarter, or whatever sum it may have been

frequently their fortune to have to expend, but are helpless if given any other sum or combination of coins. The extent to which the change making ability may be learned through concrete experience is illustrated by the case of a boy of fourteen in the third grade of the public school. He was accustomed to drive the carriage which conveyed guests from the railroad station to his father's small hotel. He could tell very quickly, for instance, what thirteen twenty-five cent fares would amount to, but he could not do the arithmetical work of the third grade in the school, nor could he do other types of making change.

The normal child during this period of learning money combinations uses his arithmetic to help out the process for unfamiliar combinations. If he cannot "mentally" manage such a problem as involves the expenditure of five cents and three cents of a quarter and find the remainder, he applies his knowledge of arithmetical processes to a solution of the problem. The defective child gets his method from oft repeated specific experience with such problems.

(c) Tell time.—The children of the second grade in the public schools are taught time units and their relationship. The accomplishment of telling time by the clock is one of too great complexity for defective children of the normal second grade age. Very few attain it at all.

Results of Arithmetic Tests for Normal and Defective Children

A series of tests was arranged in conformity with the preceding discussion. The children who took the tests were the same group as took the reading tests discussed above. As was mentioned they were chosen for their ability to read. It is possible that the arithmetic ability in a few cases was not satisfactory.

The tests for each grade were arranged to conform first to the requirements of the curriculum of 1912 for the Chicago schools. In addition to the test which would show the child's acquisition of the required work for his grade one or more additional problems were given to test his ability to make an independent use of his mechanical acquisition. It was attempted

to use for this additional test such problems as would either involve the next step to be made in the acquisition of number conceptions, or would make such use of what had just been learned as was not specifically taught in the work of the grade. This attempt was not entirely successful due to variations of procedure in different schools. In one school more of fractions was taught in the fourth grade than was required in the curriculum. In another school a much larger experience in number work was given the first grade than was the rule in the other schools. For this reason the following series of tests would need to be given to a larger number of schools, or arranged with close reference to the work of one school and given to all the children in that school, before definite statements as to the reasoning ability of normal children in the realm of mathematics could be made.

In giving the additional or reasoning tests the child was given every opportunity to show his maximum ability to think. If his first answer was wrong he was told so and asked to try again to think out his problem. This was repeated until it was apparent that he was unable to think the problem out correctly. When a correct answer was obtained by such means he was recorded in the successful column only after he had proved by his answer to other questions that the result was a thoughtful one and not a fortunate guess. He was asked to tell how he had gotten the answer,—the demand was usually put in this form: "How do you know that is right?" If he could not give his method clearly enough he was given another problem of the same kind with the numbers changed. Occasionally a child finds the right method for himself but is timid about explaining it, or is unable to formulate it.

It is needless to say that no hint of the right method for solving a problem was ever given. Much encouragement to the effect that he could get the problem if he took plenty of time to think about it was given. The child was always told to take as much time as he needed to think his problem out carefully. Each child was tested alone except for the third, fourth and fifth grade written work.

The tests for the various grades were arranged as follows:

Grade I

*Required work.**—"Objects are counted, using cardinal numbers. They are compared to develop notions of inequality and equality. . . . All the work of the grade is objective and chiefly oral." It is further recommended that the work be done incidental to the other activities of the grade, drawing, construction work, etc.

1. (Test for required work.) Counting a row of like objects.
2. (Additional.) If you have three pennies in your hand and I give you two more how many will you have then?"

If the child hesitates he is directed to find out by counting his fingers or by making marks. He is given much encouragement to do this. Some children will say they do not know how to find out in this way, but if one keeps on with the coaxing encouragement they will do it. The small child is often diffident about trying an untaught or unusual thing.

Grade II

Required work.—" . . . to read and write numbers of one and two orders; to read time by the clock to hour, half-hour, quarter-hour; to answer any of the forty-five addition and subtraction facts:

1	2	3	4	5	6	7	8	9	2	3	4	5	6	7
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
8	9	3	4	5	6	7	8	9	4	5	6	7	8	9
2	2	3	3	3	3	3	3	3	4	4	4	4	4	4
5	6	7	8	9	6	7	8	9	7	8	9	8	9	9
5	5	5	5	5	6	6	6	6	7	7	7	8	8	9

. . . To make change within one dollar; to recognize related units of measure, such as inch, foot; minute, hour, day, week; pint, quart; cent, nickel, dime, quarter, half-dollar, dollar; to use the tables of two's and three's; to count by two's to 24 and by three's to 36; to tell half of any multiple of two to 24 and one-third of any multiple of three to 36."

*Chicago Public Schools, Course of Study for the Elementary Schools, 1912.

It may be remarked that the use of the half-dollar and dollar are not attempted by most second grade teachers since the number facts to be taught make no higher combinations than twenty.

1. (Test for required work.) How much is 7 and 8? How much is 9 and 6? (Additional.) How much is 10 and 11?

2. (Required.) If you had 10 pennies and spent 6 how many would be left?

3. (Required.) a. If you had a dime and spent 4 cents for candy and 2 cents for chewing gum, how much money would you have left? b. If you had a quarter and spent 5 cents for candy and 3 cents for an apple, how much moneny would be left?

4. (Additional.) If 5 boys are in this room and 3 boys are in the other room, how many boys would have to go from this room into the other room so that then there would be the same number in each room?

Because it is often difficult for the child to keep so long a problem in mind with one repetition, the problem is always repeated immediately as follows. Do you see how it is; we have 5 boys here and 3 over there, but we don't want it that way, we want the same number in each room; how many would we have to send over there?

If the answer to this problem is correctly given the proof of a correct process lies in the answer to the question. *How many will be in each room then?*

5. (Additional.) a. If 1 pencil costs 2 cents, what will 4 pencils cost? b. If 5 pencils cost 10 cents, what will 1 pencil cost? (As may be seen by the table below, this problem is not one within the powers of the second grade child.)

Grade III

Required work.—Miscellaneous problems, involving one step only and making use of the units of measure previously studied—inch, foot; minute, hour, day, week; pint, quart; cent, nickel, dime, quarter, half dollar, dollar; pound, dozen—and in addition the yard, peck and bushel.

All tables to and including twelves; problems involving linear

measure; areas of rectangles found by drawing and counting, using the square foot and square yard; fundamental operations with United States money, omitting division; reading and writing numbers including five orders; fundamental operations, multiplier or divisor not to exceed two figures.

1. (Test for required work.) Multiplication Table. Care was taken to determine whether the table was rendered as a feat of mechanical memory more or less perfect, as is sometimes the case with defective children, or whether the child had a correct mathematical conception of the table. The child who understands what the table means, when he comes to an unfamiliar item of the table knows that he can count from the last familiar item to gain the required unfamiliar one.

2. (Test for required work.) Fundamental operations:

a. $\begin{array}{r} 2813 \\ -1482 \\ \hline \end{array}$ b. $\begin{array}{r} 3421 \\ \times\ 26 \\ \hline \end{array}$ c. $12\overline{)36281}$

3. If you had a dollar and spent 47 cents how much money would be left? This problem was used to see if when in any case the problem was too difficult a one to do "mentally" a higher process than the one resorted to by the second grade in such situations was used. The second grade child could only make marks to find the answer to an unfamiliar combination. The third grade child has the advantage of the process of subtraction with "borrowing."

4. (Additional.) If five pencils cost ten cents, what will three pencils cost?

5. (Additional.) a. If you had twelve cents and lost half of your money, how much would be left? b. If you had fifteen cents to divide equally among three boys how much would each one get?

Grade IV

Required work. Area of rectangles, dimensions limited to like integral units.

Time, including the number of days in each month; methods of proving the fundamental operations, terminology used in funda-

mental operations; reading and writing numbers of not more than two periods; problems, introducing bills, involving the common measures previously studied and using incidentally the half, third, fourth, sixth, eighth, ninth, twelfth, and sixteenth, involving no remainders; areas of irregular plane surfaces which may be divided easily into rectangles; perimeters of rectilinear plane figures; mile and rod; multiplication: multiplier, and any two- or three-digit number; proofs; division: divisor, any two- or three-digit number; proofs.

1. (Test for required work.) $48\overline{)64911}$.

2. (a) ½ of 12 = (b) ⅓ of 12 = (c) ¼ of 12 = (d) ⅙ of 12 =

3. (Additional.) a. Which is larger a half of something or a third of the same thing? b. A third of something or a fourth of the same thing. c. A fifth of something or a tenth of the same thing?

In general a correct answer is given for *a,* but frequently a wrong one for *b.* The problem may then be put as follows: which way would you get the largest piece, if you were one of the three boys who divided a pie among themselves or if you were one of four boys? The normal child gives the correct answer. Then: If you were one of three boys what part would your piece be? If you were one of four boys? Which, then, is the larger, a third or a fourth? The normal child quickly sees the principle of such problems and answers similar following ones correctly. The defective child, though he may be brought to decide correctly over and over again to which group he should belong to get the larger piece, makes the same type of error with the next similar problem abstractly presented.

4. (Additional.) If you had twelve cents and lost two-thirds of your money, how much would you then have? This problem contains two new things; a consideration of two-thirds, and the use of it as a quantity in a problem. If the child hesitated long or seemed nonplussed by the complexity of his problem he was asked, How much is two-thirds of twelve? If a correct answer was obtained, then the further encouragement was given in this form: Then tell me, if you lose two-thirds of your twelve cents how much is left? Of nine fourth-grade

children who passed this test, four needed such encouragement.

5. (Additional.) You had some money and lost two-thirds of it and then there was eight cents left, how much did you have at first?

This problem, as may be seen by Table XLVI, is too difficult for the fourth grade.

Grade V

First half-year (semester) of the grade. Fractions.— Concretely and orally; fractional equivalents; sum or difference of any two fractions within the limits of halves and sixteenths.

Second half-year (semester) of the grade. Fractions.—Addition, subtraction, multiplication, division, comparison, and ratio of fractions. Suggestion: fractions arranged in as many different pairs as possible: $1/2 + 3/8$; $1/2 - 3/8$; $1/2 \div 3/8$; $1/2$ compared with $3/8$ (ratio); $3/8$, compared with $1/2$; $1/2$ of $3/8$; $3/8$ of $1/2$.

1. (Test for required work.) $1/2 + 3/5 =$

2. (Additional.) If four dozen apples cost $1.50, what will three apples cost?

Table XLVI shows the number of children of each grade who succeeded with the tests as far as each individual was able to go. Each child was given all the problems included in higher grades with which there was a possibility of success. Each grade was given such problems of lower grades as were not implicit in the work of the grade being tested.

Examination of the table shows that with each grade success was almost universal with the required work of the grade. The numbers in bold type at the head of each column indicate the problems testing required work. The few failures in required work may have been due to the fact that the children were chosen for satisfactory reading ability. The results of the tests with defective children are given first in the absolute numbers and in the line below reduced to a scale of seventeen. The table shows that about two-thirds of the defective children were able to accomplish the required work of the second grade; one-third had learned the multiplication table and one-sixth had learned to multiply. The success of the defective children with the addi-

TABLE XLVI
Results of Arithmetic Tests

		First Grade		Second Grade					Third Grade					Fourth Grade					Fifth Grade	
Grade	Number	1	2	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2
I	17	17	15	3	3	(a) 3	1	(a) 5												
II	17			17	17	(a) 17 (b) 14	13	(a) 13 (b) 1												
III	17					(a) 17 (b) 15	13	(a) 16 (b) 13	17	16	15	5	(a) 17 (b) 16							
IV	17										17	11	17	17	(a) 17 b, c, d 14	14	9	1		
V	17													17	17	17	16	15	15	10
Defective	46	45	44	38	34	(a) 33 (b) 26	22	(a) 25 (b) 15	18	(a) 17 (b) 9	10	11	(a) 17 (b) 16	0	(a) 15 (b) 5 (c) 2 (d) 2	1				
Defective reduced to scale 17		16.6	16.2	14.0	12.5	(a) 12.1 (b) 9.5	8.1	(a) 9.2 (b) 5.5	6.6	(a) 6.2 (b) 3.3	3.6	4.0	(a) 6.2 (b) 5.9	0	(a) 5.5 (b) 1.8 (c) .7 (d) .7	.3				

tional work of the grades where it is indicated does not mean that the mental process of such individuals was equivalent to that of the children belonging to those grades. An uncritical cross section type of test may lead one to infer that such is the case. It is in watching the defective child in the schoolroom that one comes to realize that he does not, for instance, originate the process of counting marks to gain new number combinations but the process must be drilled into his mind with more or less repetition.

The youngest of the defective children had had four times as much school experience as the first grade children, and twice as much as the second grade children. It is probable that the youngest of these children and certainly the older ones, had had so much experience with the money problems of the second grade, for instance, as to make the result in effect that of drill.

Reference to the table shows that problem 5b under the second grade belongs to third grade abilities. The second grade child has no knowledge of division. Many second grade children attempted to solve the problem by an arrangement of marks but became confused in the process and gave up.

Methods of Solving Problems.—The first grade child finds out combinations under ten by counting his fingers. A few can be induced to make marks on paper. This grade, however, uses pencil but little and this probably accounts for the child's disinclination to use this method. Care was always observed in the examiner's encouragement of the child to use the pencil to stop short of actual showing this new method of representing his number situation. The first grade child fails with the finger method for combinations above ten since he has no more fingers and must use some a second time in the process of gaining such a combination. Though he attempts to do so the process is too complex and he fails to get a correct result. Older children who must resort to counting to find large combinations can use the finger method successfully. The first grade child fails in subtraction of numbers above five because of the difficulty he finds in using the forefinger of one hand both to count and to represent one of the items of his problem.

Of the second grade children nine could give the combinations of the first problem automatically, that is they did not need

to count. The others counted either fingers, marks, or silently. In the method of silent counting the child did not have the combination so thoroughly learned as to do away with counting altogether, but he could represent the situation "mentally," by means of some type of imagery not reduced to concrete means such as marks.

Of the defective children five could make such number combinations automatically.

The second grade child does the problem of 3a and 3b with the use of marks. The failures with 3b were due to the necessary complexity of many marks. roblem 5a was solved by counting by 2's or by making marks of four groups of two each.

Each second grade child was given problem 3 of the third grade group. Each child began industriously to make a hundred marks, but because of the length of time necessary for such a procedure was not permitted to finish the problem.

The third grade children had for the most part made the multiplication tables of 4's and 7's, the tables used for the test, automatic with only an occasional stop to count up for an unfamiliar item. Of the defective children six had gained so much facility with the tables. Twelve defective children could recite the tables correctly by counting up from each last item. Some of the defective children had a more or less complete mechanical acquaintance with the tables, but when memory failed they broke down with no method of finding the unfamiliar item.

The third grade child solves problem 3 either "mentally" or by means of subtraction. The failures of the two third grade children were due to the complexity of the double "borrowing."

Problem 4 is too difficult a one for the third grade, but is more nearly suited to fourth grade abilities.

Of the fourth grade children the five of the first school tested had had little of the required work with fractions. Their experience had been only with the fraction one-half. The three failures with 2a, 2b, and 2c were in this group, and consequently the three failures with problem three; all of the five failed with problem four. Problem five is too difficult for the fourth grade, but is suitable to fifth grade abilities.

XI

FACTORS INVOLVED IN THE MENTAL CLASSIFICATION OF CLINIC CASES

Throughout this study the reaction of feeble-minded children seen at the clinic has been compared with that of the normal children of the schools. There does not exist any fixed accepted standard, except the arbitrary one laid down by the Binet tests, for distinguishing the feeble-minded from the mentally normal. There come to any general clinic many different types of cases of social deviation. In the Juvenile Court Clinic the cases are of moral deviation; in the public school clinic the cases are those which show unsatisfactory reaction to the school situation, of conduct or of progress in mastering the subject-matter of the curriculum. It is the function of the clinic to determine from what cause this social deviation springs. The causes may be in the mentality, the environment, the physical condition, or some peculiarity of individual interest or temperament. One or all of these may combine to produce a deviation which brings the child into the clinic for classification and advice.

The first duty of the psychological clinic is, naturally, to separate the normal in innate mental ability from the defective. The lower grades of feeble-mindedness are apparent to every one. The defective reaction of the imbecile to almost every conceivable situation is so marked as never to be overlooked, at least after the child is five or six years of age. There is, however, a group at the upper end of the moron class which is not so easily detected.

This type is perceptually bright; can reproduce past experiences in conversation and so give a superficial impression of brightness; is sometimes even loquacious; may be given to bragging a bit and so give the impression of possessing those powers of imagination from which high standards of action are derived; are ready in promises of good behavior; can orientate themselves in a large city and take proper physical care

of themselves among its dangers; if working, they can often perform satisfactorily, certain types of routine work sufficiently well to make them self-supporting. How to separate this class from that large class of children who are not defective but backward, pedagogically considered, frequently becomes a difficult task for the clinic psychologist. Holmes (21) discusses this problem under the title of "Curable and Incurable Backwardness." He says: "If a child is curably backward, he, by that fact alone, enters into a great class of children retarded from any cause whatsoever; if he is incurably backward, he enters into another great class commonly called feeble-minded or mentally defective. Such a distinction is fraught with the gravest practical importance for the child and all concerned with him. The determination of this vital step is one of the most important in making a diagnosis. Sufficient is it now to say that the distinction does not rest upon any symptom-complex or appearance of the child alone. Curably backward and incurably backward children often look exactly alike; know about the same amount of school lore; act about alike in society, and sometimes even,—if there is any advantage either way, the incurably backward or feeble-minded child has it."

Holmes' method of determination mainly rests upon the developmental history of the child in connection with his present physical condition. If he finds in the past history nothing to lead one to suspect that the child has suffered a brain lesion, and if the present physical condition is one which needs correction, he is classed as curably backward.

This basis of classification, however, removes the case from the field of psychology and places it in the field of medicine. The child's developmental history is certainly of very great importance for the clinical psychologist, but no such history, however full it may be of suggestions of brain lesion, can establish the extent of such lesions or their effect upon mental functioning. It is in the province of the psychologist to so investigate and analyze the child's mental complex as to show the quality and extent of his mental defectiveness if such exists. The line, or as Tredgold terms it, "the gulf" which divides the highest

mental defective from the normal has been indicated by various writers who have become acquainted with this class where its individuals have gained entrance into institutions for the feeble-minded. The standardizations of various authors have been brought together by Holmes (21):

By Goddard (15). *Moron:*

High-grade: can do fairly complicated work with only occasional or no supervision; can run simple machinery, take care of animals; only unable to plan.

By Barr (22). *Imbecile:*

High-grade: trainable in manual and intellectual arts.

By Binet (23). *Feeble-minded:*

Every child is feeble-minded who knows how to communicate with his fellows by word and by writing but who exhibits a retardation of two or three years, in the course of his studies, unless that retardation should be on account of insufficient training.

By Tredgold (24). *Feeble-minded:*

First-grade: can make tolerable progress in elementary school work; can write a simple letter, read children's books, can perform simple arithmetical exercises mentally. Can do good manual work.

In the above definitions Goddard and Tredgold evidently have in mind a qualitative distinction between the high-grade defective and the normal. Barr and Binet indicate that the distinction may be quantitative. Goddard emphasizes the qualitative distinction in his last clause, "only unable to plan." It is this distinction which the writer uses as the dividing line between the normal and the defective. In the foregoing discussion of tests where the types of reaction may be distinguished as those of *planned, trial and error,* and *chance* the last two have always been found to be characteristic of the feeble-minded class and cases are classified as such if their invariable reaction to tests is below that of the planned or consciously controlled reaction type and when the child's history is in conformity with the mental plane the psychological tests determine for him.

The histories of these individuals show them quite lacking in the ability to plan their conduct in conformity with the complex requirements of civilized life in such a way as to make them really a part of the social class in which they may be found. The child's reaction to the home situation, the school situation, and his type of moral delinquency show, as well as the mental tests, the inability of this type of child to plan or reason. The parents of such children complain of a lack of responsibility of the child in the home life. He cannot be trusted as the other children to go on errands or to conduct himself properly in other ways. The teacher says that he does not learn and makes poor progress in the school. When his acquirements of school lore are examined, it is found that he has been capable of learning more or less in a mechanical way; he makes some degree of progress in reading and arithmetic but the working over of any learned content to fit the needs of a new situation is beyond his ability.

The arithmetic gained by the child who may be classed as mentally defective is merely that of a mechanical nature. Such applications as he can make of his knowledge is small in extent and usually the result of oft repeated bits of specific experience.

However much he may be able to learn to recognize printed words, he is not able to use reading to an appreciable extent in gaining organized bodies of knowledge. The use of reading and arithmetic tests and other tests involving the use of symbols can be made to show the extent to which he is lacking in the ability to use abstract or symbolic materials of thought. The use of reading, writing, and arithmetic as tests of mental ability are discussed above.

That part of the child's history which relates to the school must take into consideration grade with reference to age and attainments with reference to the curriculum. One finds many large defective children in grades a year or more behind that which corresponds with the chronological age, but at the same time far in advance of their attainments in school subjects.

The high grade defective child often becomes a dilinquent of a more or less serious character in the neighborhood, because

he is not able to apply to his own conduct such formal rules of conduct concerning the rights of others, as he may have been taught in the school or other social agencies.

The type of delinquency or other social reaction shows, frequently, a correlation with mental ability as determined by other tests. The defective delinquent is usually the follower of a more capable companion who plans the escapades in which they engage. The delinquent is a tool or a dupe in the plan of others. The defective's type of delinquency is simple so far as its mental content is concerned, however serious it may be in its social or economic aspects. The fourteen-year-old boy who robbed his mother of a sum of hoarded money, and then tied himself and did other things to simulate an attack from the outside was not a mental defective. The twelve-year-old boy who organized and led a gang of older boys in a robbery of a large jewelry store, escaping successfully with the booty was not a defective. The fourteen-year-old boy who on several occasions went into unguarded houses and wantonly destroyed things, repeating the offense, though each time he was apprehended and brought before the Juvenile Court was a defective. The boy who at fourteen years of age had appeared before the court fourteen times for robbery, but who each time carried out the plan of some other boy who escaped upon the approach of the police was a defective; as was the boy of twelve who engaged in a robbery of large extent with some others and selected as his part of the booty all the pennies of the collection, leaving to the others the bills of large denomination.

Such popular types of evidence discussed above can be accepted of course only as indicative of a possible mental status. They must be used with judgment. The parent may place his expectations of responsibility too high; the child's progress in the school may be influenced by other factors than that of mental ability; and many children in whom there is no hint of mental defectiveness become delinquent. Formal tests of mental ability must exercise their function either of corroborating or disputing the social judgment.

A formal test of mental ability on the other hand must

always be carefully evaluated with reference to the situation in which the child is found. Such care is especially demanded under the conditions of a clinic for delinquents. The examiner must also be careful to distinguish a type of reaction due to temperament from that due to defective mental ability. The exceedingly shy child or the child who lacks confidence in himself may react to tests in a different way than his mental ability, uninfluenced by such temperament, might permit. An emotional upheaval such as a delinquent may suffer is sometimes succeeded by such mental apathy as prevents normal reaction to the tests which require judgment or a high degree of control of attention. One such case was that of a boy of sixteen who had graduated from the eighth grade with honors, had done the work satisfactorily of a trusted errand boy in a large bank, was a reader of classical types of literature and had organized bodies of historical and geographical data gained from his reading, but failed in nearly all formal mental tests given him. The classification of this boy's mental ability could not be based on his reactions to formal tests.

One must also be able to distinguish unfavorable reactions due to the deteriorations or disturbances caused by certain mental or nervous diseases from those due to mental subnormality or defectiveness.

Thus school and social history and the evidence of formal tests determine whether or not the child is normal or below in mental ability. If his reactions go to show that his ability to learn is only mechanical; that he is not capable of making new applications of the content of previous learning, he is classed as mentally defective, or, as Holmes terms it, "incurably backward." If he is classed as normal in mental ability, then, the cause of his defective reactions to the school and social situation must be sought in physical conditions, social environment, individual peculiarity of temperament or interest or mental complex. Each one of these possibilities opens a new realm for psychological investigation.

This, then, is the proposed criterion for discriminating the normal from the subnormal or mentally defective. In order to

establish valid standards in the classification of individual cases th physician and the psychologist must cooperate. We need more knowledge than is now available of the mental effects of certain curable and incurable physical conditions and defects. Such problems as the mental effects of malnutrition, or the effect upon certain learning complexes of defective vision and hearing require careful observation and correlation over long periods of time of the mental and physical functionings for their solution. Until much more of such knowledge is available many individuals can be only tentatively classed as curably or incurably backward.

This basis for the determination of the mentally defective is in conformity with the view of Stern (25) in his discussion of "The Nature of Intelligence." He says:

"Naturally, we cannot begin our work without a preliminary definition of intelligence, however provisional it may be. And this definition must be neither too broad nor too narrow.

"Many psychiatrists have used a definition of intelligence that is too broad. They use intelligence, in fact, to include mental attainments of all kinds, all those mental qualities, then, that are not volitional or emotional. If this position be taken, it follows, evidently that the examination of immediate memory, of ability to learn, of range of information, of fidelity of report, or of discriminative sensitivity is just as much a constituent part of intelligence as the examination of ability to apprehend, to synthetize, of capacity to judge, to conclude, to define, to criticize, etc. Again, a question that is very important for us, viz.: to what extent intelligence really enters into these first-named activities, and whether and in what way it shows signs of its presence in them, becomes absurd. But the advance made in the recent development of intelligence testing, in contrast to the uncritical determination of mental level by any sort of questions and tests, consists in the fact that we not only limit intelligence by setting it over against the emotive and volitional nature of an individual, but also ascribe to it a definitely restricted place within the mental functions.

"This delimitation of the sphere of intelligence that is even

now essential cannot be affected, in my opinion, from a phenomenological, but only from a teleological point of view. In fact, my definition is this:

"Intelligence is a general capacity of an individual consciously to adjust his thinking to new requirements: it is general mental adaptability to new problems and conditions of life.

"This definition differentiates intelligence clearly from other mental capacities.

"The fact that the adjustment is made to the new distinguishes intelligence from memory whose fundamental teleological feature is the conservation and utilization of conscious contents already given.

"The fact of adaptation, again, emphasizes the dependence of the performance upon external factors, on the problems and demands of life, and thus distinguishes intelligence from genius, whose nature is to create the new spontaneously.

"Finally, the fact that the capacity is a general capacity distinguishes intelligence from talent the characteristic of which is precisely the limitation of efficiency to one kind of content. He is intelligent, on the contrary, who is able easily to effect mental adaptation to new requirements under the most varied conditions and in the most varied fields. If talent be a material efficiency, intelligence is a formal efficiency.

"I trust that these distinctions may serve to lessen the confusion that has been current. It is not so long ago, indeed, that in psychiatry 'information tests' were carried on as 'intelligence tests,' thereby confusing memory and intelligence. And we often, even nowadays, find intelligence, and talent confused in everyday life. In school, for instance, a teacher of a special subject like mathematics, who perceives the special gift of a pupil in that field, may easily come to believe without further evidence that this pupil has general ability, or in other words, to rate him as an intelligent pupil.

But we should not interpret this delimitation to mean the erection of sharply distinct faculties, as in the old faculty theory. Intelligence, for instance, does not function by itself and memory by itself; rather, every operation of memory is more or less

impregnated with intellectual functions and vice versa: the extent of this interconnection can be indicated only by the correlation of the tested symptoms. But just on account of this composite character of every actual mental process it seems to me that the definition of intelligence I have given above is indispensible as a regulative principle for further investigation; I mean that any sort of perceptive, memorial or attentive activity is at the same time an intelligent activity just in so far as it includes a new adjustment to new demands."

With this principle for guidance a system of mental grading independent of age may be constructed. A child of any age may be on the same mental level as a child of any other age, though their acquisitions of knowledge due to different types of experience and training may be quite dissimilar. For this purpose further work is needed to devise such tests as are related to the types of experience or innate development as are common to all children of different ages. These tests must also be of such character as to be adapted to the specific opportunities for specific experiences of the particular atypical child to be examined. Careful discrimination on the part of the examiner of the relation of the tests to experience will prevent such erroneous conclusions concerning the child's ability to reason or interpret as have been discussed above with reference to picture tests, definitions, etc. Tests must also be distinguished with reference to the two phases of mental activity which are concerned in a judgment of general intelligence. These are, as has already been intimated, the individual's rate of acquisition of mechanical learning and his ability to apply it upon demand to a new situation.

The most productive source for such study is probably that presented by the public school. Here all children are subjected to the same set of experiences; they are instructed in certain types of mechanical acquisitions such as the recognition of words and arithmetical processes which they are expected to use in further acquisitions of knowledge. The reactions of normal and atypical children to the school situation may be profitably analyzed for the establishment of standards of normal reaction

to this almost universal set of stimuli, and the discrimination and types of defective reaction. Such work upon defective children as that of Chotzen (26) can be of little value until this has been done. The children studied by Chotzen through the medium of the Binet-Simon tests were selected out of the school and segregated in the Hilfsschule because of their defective or atypical reaction to the school situation. It would seem that it is only an analysis of this or other types of social reaction in connection with the many other factors of temperament, home or other social environment, physical condition, etc., which may be of value for diagnosis with reference to educational treatment or social or institutional classification. These other factors it is not now our province to discuss further than to quote from an article by Katzenellenbogen (27) who enumerated many of them in connection with the discussion of the relation of epilepsy to mental tests.

"The French psychologists, Binet and Simon, prepared this test primarily for the use of normal children, in order to gain a more exact and uniform basis for placing children in the corresponding school grades. The necessary assumption for the arrangement was the uniformity of conditions, under which a child of a given age was supposed to be. A child for instance, of the age of nine, should have according to the arrangement of French schools such and such knowledge; the tests were made a posteriori with a selection of the highest percentaged questions, answered by children of a given age. Having a practical point of view in mind, this test has been of the greatest value in France and could be easily applied as a routine examination of children in any country, with the necessary modifications. Although native ability plays an important rôle in such a test, the training is an essential condition of the child's success. If a child failed, and was retarded for instance two years the Binet test would diagnose the case as "retarded," without giving the cause for retardation. Such a retardation might be due to mental dullness—an inborn condition—or to lack of previous educational experiences, to sickness, adenoids, psychopathic timidity and nervousness, or

other accidental causes. It is even possible that one should attribute to a child which is only one year behind his normal according to the Binet-Simon test an especially good native mentality, as he in spite of some cause (epilepsy for instance, as we shall later have the opportunity to see) has fallen no more than a year behind.

"We thus see, that difficulties arise even in dealing with normal children and that even in public schools, this test would cause teachers who lack a psychological or more important even, a medical knowledge, to commit graver mistakes with the Binet-Simon test, than they otherwise would. I can however say, that every teacher—provided he is of the same sex as the child,—would be able, when properly instructed, to apply the test under one condition, that the answers should be recorded verbatim, scored with the aid of a stop watch. The real problem, however should begin at this point, and every child having the record of failure, that is every child having the same opportunity as the others, which would fail, should be turned over to a psychopathologist (with medical knowledge) who would have the task to investigate the cause. Thus applied, the Binet-Simon test even in its present form would be of great value, as it would lead to the individualisation of pedagogical attention and would result in proper segregation. Such a procedure however, would under the present arrangement of the test, although pedagogically interesting and valuable, be of little use to the scientific phase of the problem.

"The apparent success of this test with normal children led the French psychologists to apply it as primarily devised for pedagogical purposes and for the use of normal children, to abnormal ones. They did not even stop at the using of this test upon children, but thought it possible to apply it to adults as well. The necessary hypothesis which led them to such an application is a psychogenetic point of view, that imbeciles reach a certain maximum of development and then stop for ever and that theerfore, an imbecile of twenty-five years may be compared with a child of five, if such an individual fails in the test devised for a child of six. Kuelpe, justly questions

this point of view, claiming that one has no more right to compare imbeciles with normal children of a certain age, than to claim that dwarfs are physically children who did not develop above a certain age. This point of view is indeed not new. Wildermuth tried to adapt this point of view to idiots, but failed to convert others to his way of thinking. Let us consider the case of an imbecile of eighteen, whose mental age according to the Binet-Simon scale is six years. As a rule such a low grade imbecile is far below a normal child of that age regarding adaptability to new surroundings, or ability for learning or being trained. He may exceed on the other hand a normal child in the knowledge of money, counting, etc., which knowledge he has acquired during the twelve years of additional life. Finally, the sexual maturity will disclose a new life of inner psychic experiences unknown to the child. The same dissimilarity exists between a child and a dwarf, who is rather a caricature of an adult's body; in like manner the imbecile's mind is a caricature of a normal adult's mind.

"This objection to a grading like the Binet-Simon could be overcome, if instead of years, a system of grading independent of age would be substituted. For instance a given complex of tests would indicate a certain grade of development. The same complex with graded difficulty would indicate a higher degree of mentality. Such a grading would necessarily be a quantitative one in most of the tests. The Binet test has some of its tests arranged in this way, such as for instance the impressibility test for words and digits, unfortunately without a systematic arrangement. In such an arrangement the grading would also be artificial, but it would do away with the confusion, especially among laymen, that imbeciles are children with a stunted development.

"Imbecility is a collective diagnosis of many conditions not only dissimilar regarding etiology but also in its manifestations. It is often difficult to differentiate, where the imbecility ends and the normal dulness begins. Psychiatry calls imbecility an abnormal state of mind with a manifestation of inferior intellect, a state which is either of congenital origin or which

had its origin in some pathological conditions occurring in earliest childhood.

"The one diagnostically important point in imbecility is the impossibility of any marked improvement and the lack of the capacity for gaining knowledge by experience. The memory and ability for gaining even an extraordinary mechanical knowledge of facts can however be intact. I remember seeing in Rome, N. Y., at the Custodial Institution, an imbecile of a very low grade, who was able to recite the capitals of all the States and knew a great many historical data. These facts he repeated however in a parrot-like manner without inner understanding. To make a diagnostical point of calling imbecile all those who are three years retarded in the Binet-Simon test, means to create a new diagnosis, only valuable in its application to the Binet-Simon test. There is no doubt, that there is a possibility of training an imbecile along some lines, where mechanical knowledge or memory is concerned, so that an individual whose grading was dependent on mechanical appliance and diagnostication, after a certain training would test perhaps no more than a year or two behind his age after a week's training thus reaching the degree of backwardness or dulness. As on the other hand, a dementing process may set in slowly in a child (juvenile paralysis, dementia praecox, impossible to perceive in their initial stages, without mentioning epilepsy) a previously normal child might be classified as an imbecile. As we previously mentioned, imbecility is a well defined although not always an easy diagnosis and the Binet test is not adaptable to the making of a diagnosis of imbecility. Pedagogical psychologists too easily lose track of the fact, that imbecility is a term of pathology and not simply a gradation of mental ability. Such a diagnosis should be left entirely to a medical psychopathologist. We do not make a diagnosis based on the tests alone but on the whole clinical picture which must correspond to the findings of the test."

XII

QUALITATIVE CLASSIFICATION OF TESTS

In conformity with the principle of the qualitative evaluation of reaction to tests of mental ability the Binet-Simon, the Healy-Fernald and tests of reading and arithmetic are classified below to indicate the mental process which is concerned in the performance of the individual tests. This classification indicates levels of intellectual ability from the highest to the lowest levels, where mental defectiveness belongs. The reasons which underlie this classification of tests appear in the earlier discussion of this paper.

Level I. (Normal Level)

Process: reasoning or adaptation of a learned content to suit a changed situation.

Tests: Counting backward.
Criticizes absurd phrases.
Uses three given words in a sentence.
Interprets picture.
Defines abstract terms.
Derives the sense of a mixed sentence.
Solves paper cutting test.
Reconstructs a triangle.
Test III, construction Puzzle "A."
Test IV, construction Puzzle "B."
Test V, Puzzle Box.
Test IX, X, and XI, Code test group.
Distinguishes between morning and afternoon, months of year, and date (when conception of time relationship is involved).
Interprets figurative literary material.
The use of arithmetical processes for the solution of new problems.

Level II

Process; Conscious choice of several possible reactions to correspond to certain already learned classifications.

Tests: Compare weights. (Is not a test of sensory discrimination, since it is the classification *heavy* and *light* which is determined.)
Distinguishes between morning and afternoon.
Defines concrete nouns.
Defines abstract terms.
Compares faces from aesthetic standpoint.
Describes picture.
Compares two remembered objects.
Indicates omissions in pictures.
Problem questions.
Gives rhymes.
Solves problems from several given facts.
Solves question concerning President and King.
Summarizes observations made by Hervieu.
Tells a story after reading.
Use of arithmetical formulae for the solution of type problems.

Level III. (High Grade Defective)

Process; conscious choice or arrangement of material to correspond to a model concretely presented.

Tests: Copies square.
Copies lozenge.
Game of patience.
Indicates omission in pictures.
Test I, Introduction Puzzle.
Test II, Special Picture Puzzle.

Level IV.

Process; mechanical or rote learning.

Tests: Tests of immediate memory.
Test VIII, learning of arbitrary associations.
Executes three commissions.

Naming colors.
Counting.
Making change.
Recognition of money.
Copies drawings from memory.
Months of year.
Date.
Recognition of printed words.
Arithmetical processes.

Levels I and II belongs to the normal grade of mental ability. That child is normal or socially satisfactory who can think for himself, as indicated by the tests of Level I, or who learns with facility in such a way as may be indicated by the tests of Level II. The mental processes of the upper grades of the defective classes are made upon Levels III and IV. Though all normal individuals in every type of mental activity must at some time belong to Levels III and IV, it is characteristic of the normal type that it advances beyond this. It may be established as the characteristic of the defective type that he does not advance in a general way above these levels. Defective individuals may vary in their ability to pass over from Level III into Level II in certain specific ways. The defective individual's activities in Level II take place only after such prolonged experience of the specific types underlying the mental processes involved as to make the result finally approach that belonging to Level IV, mechanical or rote learning. It is in this sense that tests should be evaluated with reference to age and, that, only as age may be related to certain types of experience.

The classification may be continued downward to include more fundamental processes, such as sensory discrimination, divorced largely from such constructive activities as are indicated in Level IV.

XIII

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A STUDY OF RETROACTIVE INHIBITION

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IV

A. ORIGIN OF THE PROBLEM

Since the rather exhaustive work of Müller and Pilzecker, investigating various aspects of memory, Retroactive Inhibition[1] has held an unquestioned place among the principles of Psychology. It follows naturally that it may play an important part in our mental activities. Undoubtedly, it is to be considered in the construction of any system for the attainment of the highest efficiency in learning for recall, with the least expenditure of mental energy. Furthermore, it seems in accordance with popular science, and with a certain scientific tendency towards the assertion of the unification of both mental and physical energy, that if, after studying one task, the attention is turned to a second task immediately upon the completion of the first, the first task will not have the same recall value as if the second task had not succeeded the first.

At the beginning of this work the author took these conclusions as well grounded and, sharing the consensus of opinion among psychologists that the effect of retroactive inhibition is quite marked under certain conditions, proceeded upon this basis. In the work of Müller and Pilzecker the existence of retroactive inhibition was seemingly definitely established. However, into a consideration of its various aspects they did not enter. It seemed, then, of scientific value to know the more minute details of the workings of this process. In carrying out this work, it was the author's purpose to investigate the nature of the working of retroactive inhibition, to produce curves evidencing its relative influence with the lapse of time subsequent upon learning, to consider the nature of these curves, and to note important subsidiary phenomena as they might appear in the course of the experiment.

[1] For convenience of expression, the writer deals with retroactive inhibition, throughout this paper, as if it were really defined as an *active* mental process, rather than as an *effect* of some activity upon the permanence of a closely preceding activity.

The experimental work upon this problem was begun in the summer of 1912. The work done at that time, though bearing out the general conclusions of this paper, is not considered sufficiently accurate and exhaustive to serve as a base for any definite conclusions; the development of a more accurate method being its chief service. The work upon which our conclusions are based was carried out in the school years 1912-'13, 1913-'14, and the summer of 1913. In Experiments I to XII seven subjects—six men and one woman—were used. In Experiments XIII 34 subjects—eleven women and twenty-three men—were employed.

B. WORK OF OTHERS—LITERATURE

From 1892 to 1900 Müller and Pilzecker, two German investigators, continued the work on memory, begun some years previously by Müller and Schumann. They conducted a series of forty experiments, endeavoring to bring out the main laws of association and inhibition as they appear in connection with the learning of nonsense material. Their report of these experiments appeared in the *Zeitschrift für Psychologie,* 1900, *Ergänzungsband* 1. Their work is an example of untiring effort in the quest for knowledge. We are indebted mostly to them for our present conception of the Perseveration Tendency, Generative, Effectual, and Retroactive Inhibition. It is the last, Retroactive Inhibition, which forms the main subject of our discussion in this paper. Closely related to our phase of the memory problem they conducted nine experiments, (Versuchsreihen 29 to 37). The general tenor of their method in these experiments is as follows:

The subject is shown a series of twelve nonsense syllables, written on a strip of paper, and placed around a twelve-sided prism in such a way that a syllable corresponds to each of the twelve sides of the prism. This prism is revolved behind a metal screen, containing an adjustable slit through which the subject may view the syllables as they pass on the revolving cylinder. The syllables are repeated a certain number of times in trochaic rhythm. The number of repetitions for any experiment is kept constant. The variability of the experiment lies in the arrange-

ment of the mental activity of the subject during the interval between the learning and the test. This interval, for simplicity of explanation, may be divided into three parts, (1) a rest, (2) mental activity, usually consisting of an after-series (Nachreihe), *i.e.* the attention is turned to the learning of a new series of syllables, and (3) a second rest period. Then follows the test. For testing the syllables, the apparatus mentioned above, together with a Hipp chronoscope and lip-key, or sound-key (Schalltrichter), are introduced into an electric circuit. The chronoscope is adjusted for running with a broken circuit. A slide, to hide the syllable from the subject's view, is held in front of the slit by means of an electro-magnet just above it. The operator breaks the circuit, allowing the slide to fall, thus exposing the syllable to be tested. With the fall of the slide the chronoscope starts. The subject reacts with what he thinks to be the corresponding unaccented syllable. If he does not know, he replies "Nichts." A brief outline of eight of the nine experiments (Versuchsreihen 29 to 37) follows. The other, because of its important bearing upon the problem in hand, is given *in toto*.

Experiments 29 and 30:

The purpose of these two experiments was a comparison of 24-hour and 11-minute associations. Little more was accomplished than a mere notice by one of the subjects that employment during the rest interval, after learning a set of syllables, injured the associations of these syllables. The numerical results showed nothing of particular importance.

Experiment 31:

In this experiment a comparison was made between series learned with no mental activity closely following, and series learned with the learning of a second series following 34.4 seconds after the completed learning of the first. In the first case the average success was 48 per cent, with the average time for successful scores 2480σ. The corresponding figures for the other case were 23 per cent and 3570σ. The number of accented syllables shown in the test was 144.

(For brevity the following symbols are brought over from Müller and Pilzecker's work. H(Hauptreihe), a series learned for test. N(Nachreihe), a series learned soon after the learning of an H series. V(Vergleichsreihe), a series with no N series following its learning; r, the per centum of successes; T_r, the average time for the successes; n, the total number of syllables tested in any particular experiment.)

Experiment 32:

The general plan was the same as that of Experiment 31. The reading of the N series was begun 17.8 secs. after learning an H series. The results, $n = 162$, were: For the H series; $r = 27$ per cent, $T_r = 3230\sigma$; For the V series; $r = 55$ per cent, $T_r = 3070\sigma$. The subject indicated that he would rather not look at a newspaper, for it would make him forget his syllables. He found the best way to employ his time was to walk up and down the room, and give himself up to meditation.

Experiment 33:

Plan of Experiment 32. The reading of the N series was begun 27 secs. after the reading of the H series. The experiment was discontinued after eight days, *"weil die rückwirkende Hemmung in unbestreitbarer Weise hervorgetreten war und eine weitere Fortzetzung der Versuche überflüssig erschien."* For the H series; $r = 43$ per cent, $T_r = 2260\ \sigma$. For the V series; $r = 72$ per cent, $T_r = 2090\sigma$. ($n = 72$).

Experiment 34:

This experiment was designed to compare two kinds of series, and H_1 series, where the N series followed after 17.2 secs., and H_2 series, where the N series followed after six minutes. The accented syllables of the H_1 and the H_2 series were mixed and tested after one and one-half hours. Results: For the H_1 series; $r = 28$ per cent, $T_r = 2760\sigma$. For the H_2 series; $r = 49$ per cent, $T_r = 3000\sigma$. ($n = 144$).

The subject stated that it was better not to busy herself with a magazine during the rest period, for she had previously noticed that such activity was injurious to the recall of the syllables. It was best to allow the thoughts to wander where they would.

Experiment 35 (*in toto.*[1])

This experiment, in which Dr. Behrens acted as subject, was conducted in the same way as Experiment 32, in which Dr. Behrens was the subject, with the exception of the unimportant circumstance, that the main series (Hauptreihe) and the comparison series (Vergleichsreihe) were not read twelve times but, on account of the acuteness of the subject, were read only eight times; and with the exception of the very important circumstance that the mental activity of the subject, following the reading of the main series, did not consist in the reading of a second series of syllables. The subject had, directly after the reading of each main series, to observe attentively three different landscape pictures that had been previously prepared for the purpose, and, directly after the observation of all three pictures, to describe, as nearly correctly as possible, to the operator what he had seen in each picture. The time of observation for each picture lasted ten seconds. To be sure, a picture once used was never used again in the experiment. In order that the consideration of, and the meditation on, the pictures might not leave behind any fatigue of the subject for the test of the just previously read syllables of the main series, the work with the pictures never extended over a longer interval than two minutes, so that, if the subject had not finished the picture work after a lapse of two minutes after completing the reading of the main series, he was stopped after this period without further ado. Between the picture work and the test of the accented syllables of the main series there always occurred a rest period of at least six minutes. The experiment was discontinued after twelve days for the expected result was obtained in an unquestioned way. The main series, whose readings the picture work followed, gave with each temporal position many less successes and fewer very small times than the comparison series which were not followed by picture work. On the whole, $n = 108$, there resulted:

For the H series; $r = 24$ per cent, $T_r = 2950\sigma$
For the V series; $r = 56$ per cent, $T_r = 2490\sigma$.

[1] Free translation.

If one compares these results with those received in Experiment 32, it appears that in this experiment with picture work, at least as strong an injurious influence upon the associations was at work as that which existed in Experiment 32 through the 12-time reading of the after series. We hasten to remark that, before the beginning of this experiment, we knew, through occasional experiments, Dr. Behrens might possess a strong interest and concentrated attention with visual pictures. It does not necessarily follow, that other subjects, in experiments arranged as ours, may not give less striking results.

Experiment 36:

The savings method was used with the learning of another set of syllables for the mental activity following the learning of the main series. Results in two cases were obtained, (n=32):

An H series, requiring an average of 13 repetitions.
A V series, requiring an average of 11.25 repetitions.
An H series, requiring an average of 7.8 repetitions.
A V series, requiring an average of 6.6 repetitions.

Experiment 37:

The savings method was used. As in Experiment 35 pictures were used for influencing the fixity of the associations of the previously learned series of syllables. Results, n = 24:

An H series, requiring an average of 8.0 repetitions.
A V series, requiring an average of 4.9 repetitions.

Conclusions of Müller and Pilzecker (abridged):

1. The introspections of the subjects indicate retroactive inhibition.

2. The numerical results of Experiments 31 to 37 indicate retroactive inhibition.

3. Retroactive inhibition is the greater the more attention paid to the interpolated work.

4. Retroactive inhibition is much weaker when the interpolated work is done after six minutes than when it is done immediately after learning.

5. That the work precludes thinking of the syllables does not explain retroactive inhibition.

6. The results obtained are not due to the similarity of the syllables of the N series to those of the H series. test

7. The influence of fatigue, following the work, was eliminated.

8. The work did more than merely to weaken the condition of preparedness.

9. Physiological activity continues after reading. This is weakened by any other activity.

10. The processes underlying retroactive inhibition and the perseveration tendency are the same.

11. The objection that, because of the perseveration tendency, the associations should increase, is not valid.

12. The condition of preparedness between the first and the eighth syllables is different from that between the first and second, for the brain excitations are different.

13. The application to didactics is clear.

At the Fifth International Congress for Experimental Psychology,[1] 1912, G. E. Müller made a brief report of an investigation which was then being carried on by Frl. Heine, who was working under the direction of Professor Müller. Her results with nine subjects indicated that retroactive inhibition does not apply to the process of Recognition, when tested with nonsense syllables. Four of the subjects were tested for retroactive inhibition, according to the method used by Müller and Pilzecker. The average percentages of the four tests for the Hauptreihen and the Vergleichsreihen were 22 per cent and 38 per cent respectively.

Müller remarked that, from the results obtained, it appeared retroactive inhibition manifested itself less easily as more repetitions were given the series in the learning process.

Other than the work of Müller and Pilzecker and that of Frl. Heine, the writer is unaware of any important work done upon the subject of retroactive inhibition. As noted by Müller and Pilzecker and by Müller, a few investigators, Bigham, Von Kries, E. Meyer, in experiments with different purposes in view, have made mention of results, more or less harmonizing with

[1] Vide *Bericht über den V. Kongress f. exper. Psychologie,* 1912, S. 216 ff.

the idea of retroactive inhibition. Bigham,[1] in the presentation of numbers, colors, forms, syllables, etc., noticed more errors after an attention-engaged interval, and remarked, "The filling of the intervals hinders the memory." Von Kries[2] remarked, that the memory of a seen extent fades very quickly, if the time following the perception of the extent is filled with some other activity.

Some of the recent texts on Psychology call attention to retroactive inhibition. Pillsbury,[3] in his *Essentials;* Meumann,[4] in his book on memory; and Myers,[5] in his brief summary of the work done on memory, allude to its existence. Ebbinghaus[6] refers to it as a possible explanation for the disproportionate increase in the number of repetitions required as the "memory span" is exceeded.

C. APPARATUS

The apparatus used in the majority of these experiments may conveniently be divided into three parts.

1. A modified form of the Wirth card-exposure apparatus. This apparatus was modified and used by Dr. J. F. Shepard and H. M. Fogelsonger in their work on Inhibition. In their article reference is made to the main modification.[7] For clearness the modifications there introduced may be briefly described. In place of the cylinder with stationary electrical contacts, an all-metal cylinder, with adjustable contacts, was substituted. Around the cylinder, and beneath a surface shell, were placed fourteen sliding strips, each strip bearing a metal contact point projecting through a narrow groove in the surface shell. By adjusting these strips, any number of the fourteen points can be arranged so that contact with the insulated projecting brush will be made as the cylinder revolves. Midway between two strips was soldered,

[1] Cited from Müller and Pilzecker's articles, S. 194.

[2] Cited from Müller and Pilzecker's article, S. 194.

[3] *Essentials of Psychology,* 1913, p. 196.

[4] *The Psychology of Learning,* English translation, 1912, p. 147.

[5] *Text-book of Experimental Psychology,* 1911, Pt. I, p. 153 f.

[6] *Grundzüge der Psychologie,* 1902, S. 652.

[7] *Psychological Review,* Vol. XX, No. 4, July, 1913, p. 292.

along its middle line, leaving its edges free, a thin and narrow strip. This resulted in fourteen grooves, directly over the fourteen sliding strips, which serve to hold strips of paper bearing syllables for the exposure. This modification greatly facilitated the manipulation of the syllables.

A second modification consisted in the addition of a clutch to take the place of the cumbersome link-chain part. In using the link-chain, when more than a certain number of revolutions of the cylinder were required, the operator had to stop in the midst of the presentation process until the chain could be re-adjusted. With the clutch, all that is necessary, when the weight runs down, is to gently pull the end of the cord bearing the counterweight. The regularity of the revolution of the cylinder is not altered, and the distraction of the subject, due to the change, is negligible.

A further and minor modification was the addition of a metal projection to each of the two ratchets, thereby enabling the cylinder to be easily tripped with the fingers, when it is not desired to use the electric circuit and metronome for tripping.

2. A Hipp chronoscope for registering time.

3. A mouth-key. The mouth-key served as a reaction part for breaking the electric circuit upon the subject's receiving the stimulus word. This apparatus consists of a circular metal box, somewhat similar to a frustum of a cone, the small end of which contains an opening. The sides of this opening are shaped to fit snugly about the nose and mouth. Absorbent cotton was used about the edges to render the box air-tight when fitted against the face. The opposite end of the box contains a single circular opening with a projecting band. Over this opening is placed a rubber tambour. To the tambour is waxed a disk to which is pivoted an aluminum pointer, one end of which is pivoted to a post on the side of the box. For the other end of the pointer there is an insulated post upon which the free end of the pointer may rest. Adjacent to the insulated post is a second post in connection with the box itself. These posts are fitted for wire connection. The working of the instrument is

as follows: When the mouth and nose are placed in the opening, the face pressed closely against the edges of the box, and a word spoken, the air pressure forces the tambour outward, consequently pushing the pointer off its post, thereby breaking the circuit.[1]

A simple metronome for regulating the rate of exposure of the syllables and a commutator complete the list of apparatus.

The complete set-up may be diagrammatically represented thus, Fig. 1.

M. K., mouth-key; C., commutator; W. C. A., Wirth card-exposure apparatus (modified); H. C., Hipp chronoscope.

The working of the combined apparatus, in a test, may be briefly mentioned. The syllables to be tested are placed on the cylinder of W. C. A. in alternate grooves. One of the two slides closing the exposure slit should be pulled up, allowing the subject to see the first syllable of each pair of syllables as the cylinder revolves. With the exposure of each test syllable contact is made at W. C. A. Upon thinking of a suitable response, the subject speaks into M. K. We then have the time elapsing between the exposure of the test syllable and the subject's reaction thereto.

[1] The mouth-key was designed by Dr. Shepard for reducing, as far as possible, the time elapsing between the subject's thought of a response and his actual response as indicated by the apparatus. The lip-key is open to the objection that the quickness of its release may vary with the response-word. In fact, a clear enunciation of some words does not necessarily require its release.

The sound apparatus has the objection that for its use a relay must be inserted. This latter instrument increases the inertia to be overcome and movement to be made, both requiring time. The mouth-key is scarcely open to either of these objections. When the face is held tightly against the opening the initiation of any sound, even a whisper, affects the tambour through the intervening column of air. However, it has the objection that, for fairly long times, the subject can not maintain his position, since breathing is necessarily stopped. Consequently, in long times, the subject must allow space between the face and the instrument for breathing. When the response is thought of, movement towards the instrument must be made. It is questionable, then, whether the difficulty has been wholly obviated.

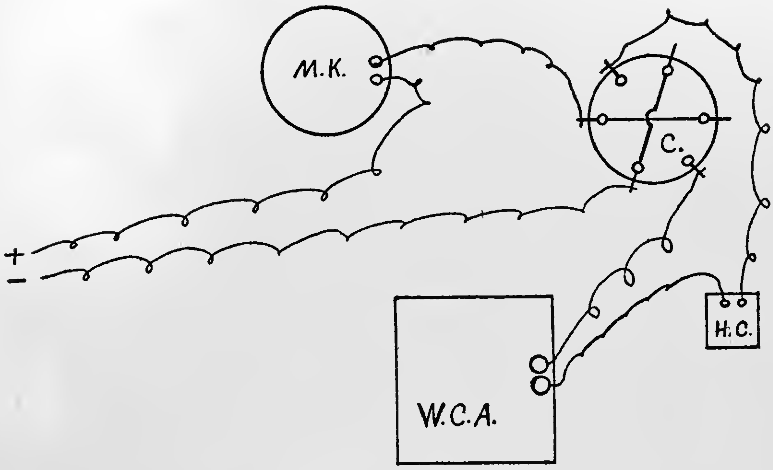


FIG. 1

D. NONSENSE SYLLABLES—THEIR PREPARATION

In the preparation of the nonsense syllables, the five vowels, a, e, i, o, and u, and all the consonants, were used. A nonsense syllable was composed of three letters, a vowel between two consonants. All syllables possible with the various combinations of vowels and consonants were made. Any syllable making a sense word was at once rejected. Syllables with the initial and final consonant the same were rejected. The remaining syllables—about 1400 in number—were written on slips of paper, placed in a bag, and thoroughly shuffled. They were then drawn by lot. Fourteen syllables were arranged in pairs, composing seven measures of two syllables each, with the following restrictions in mind:

1. The initial consonant, the vowel, and the final consonant of the first syllable should be different from the corresponding letters of the second syllable of the same measure.

2. The final consonant of the first syllable of a measure should be different from the initial consonant of the second syllable of the same measure.

3. Two syllables having an apparent sense association were not used to form a measure.

4. In the seven syllables, occupying the first-syllable position of the seven measures, all the vowels were represented, and two vowels were represented twice. The same applies to the seven syllables occupying the second-syllable position. The two vowels represented twice in the first position were not the same as those represented twice in the second position.

5. The initial letters of the seven syllables occupying the second-syllable position in the seven measures were all different. In the case of those occupying the first position, not more than two were alike.

6. The seven measures were arranged for learning so that successive vowels of the different syllables were not the same, and initial consonants of successive syllables were different. The end consonant of one syllable was different from the initial consonant of the succeeding one.

7. In a set of fourteen syllables, two syllables, with two letters of one syllable the same as the corresponding letters of the other, were not permitted.

The two syllables forming a measure were type-written upon slips of paper to fit the grooves of the exposure apparatus. The initial letter of each syllable was a capital, the other two being small pica letters. The spacing between two syllables of a measure was 2 cm.

In any experiment, when the stock of syllables was exhausted, new syllables were formed by dividing the total number of measures into three parts, the measures the subject first learned being used as the first part for forming new syllables. These measures were mixed thoroughly and drawn by lot, and new measures of syllables formed with the above seven restrictions in mind, and with the further restriction that two syllables, once forming a measure, were not used again for a measure. Usually the syllable occupying the first (second) half of a measure was used for the second (first) half of a new measure.

In a few instances errors of construction crept in but may be considered as negligible. It may be remarked that absolute equality of different series of syllables appears almost impossible.

Considering the matter of associations alone, a series of syllables, to the operator apparently free from associations, often occasions familiar associations to the subject. These can scarcely be avoided, since the associations of two individuals are often quite different, thus making it impossible for one to arrange wholly unassociated material for the other.

E. GENERAL METHOD

The general method of our Experiments I to XII may be briefly outlined. The subject, seated in front of the apparatus, is shown a series of fourteen syllables, seven measures, two syllables to the measure. The cylinder bearing the syllables is revolved by the operator at a uniform rate throughout the exposing process. The cylinder contains fourteen grooves for measures. Only alternate grooves are filled with measures. Each empty groove is exposed the same time as a filled one. Thereby the subject sees a pair of syllables for a certain time and, following this exposure, there is a rest interval of the same length. The subject repeats the syllables aloud as they pass. Equal times of exposure are obtained by the use of the metronome. Following the learning is an interval which may or may not, according to the day's position in the experiment, contain a sub-interval of mental activity. When this sub-interval was employed in mental activity, the signal used for the subject to begin was, "Work," spoken by the operator at the desired time. When the operator desired the subject to cease working, this was indicated by simply saying, "Rest." How much mental activity had to be engaged in, following the learning, was kept from the subject as nearly as possible. At the end of the interval, varying in length according to the experiment, came the test. While the subject was working or resting, as the case might be, the operator re-arranged the measures on the cylinder in an order different from that used in learning them. In the first test of each day the order of test of the measures, as compared with the exposure of them, was 5, 7, 1, 3, 6, 2, 4. In the second test of the day the order was 6, 2, 4, 7, 1, 3, 5. Only the first syllable of each measure

was shown for test. The method of test has been given under Apparatus. The operator notes the reply of the subject to each syllable shown, records the time, and adjusts the apparatus. The subject, each time after he has replied, makes the contact at the mouth-key for the next test. After the seven syllables are tested there follows a rest period, during which the operator records the introspections of the subject, and arranges a new set of syllables on the cylinder for the second learning, which follows after a rest period of not less than five minutes. Usually two series are learned and tested on any experiment day. The experiments on different days were made at as nearly the same hour of the day as possible.

In recording the responses of the subject to the various test syllables, it is to be noted that the first response—the one giving the time—is always used. A second response, though correct, is recorded but never considered as a correct response to the test syllable. The time given the subject to think of a suitable response is necessarily restricted to the limit of the chronoscope, which runs apporoximately one minute. It may be noted in advance that such long times are exceedingly rare.

The seven subjects[1] serving in the major portion of this work were:

Prof. W. B. Pillsbury,	(P.)
Dr. H. F. Adams,	(A.)

and Graduate Students,

Miss Z. P. Buck,	(Z. B.)
Mr. W. H. Batson,	(B.)
Mr. F. C. Dockeray,	(D.)
Mr. H. V. Foulk,	(F.)
Mr. C. P. Wang,	(W.)

[1] To some of these the writer is particularly indebted in that he was unable to reciprocate their service.

F. EXPERIMENTAL SECTION

Experiment I

This experiment extended over a period of thirty-two experiment days. Successive experiment days do not necessarily coincide with successive calendar days, though for the most part they do. On each experiment day two series of seven measures each, two nonsense syllables to the measure, were shown to the subject. Sixteen repetitions were given for the learning. The rate of the revolving cylinder was kept constant by the use of a metronome. The metronome was set at seventy-two beats a minute. On each second beat of the metronome the operator allowed the cylinder, bearing the syllables, to move around one point. Thus a measure was exposed to the view of the subject one and two-thirds seconds, then a blank space was exposed for one and two-thirds seconds, then another measure for one and two-thirds seconds, and so on, until the requisite number of repetitions was given. This process is designated the *learning*. Following the learning there elapsed a period of time which we shall designate throughout as the *variant interval*. In the present experiment this interval lasted fifteen minutes. The mental activity of the subject during this interval is the important variable in our experiment. In this consists our variable factor, it being our purpose to keep, from day to day, all other factors as nearly constant as possible. The plan relative to the disposition of this interval for the different days may be given as follows:

	Series A		Series B	
Exp. Day	Rest	Work	Rest	Work
1	15	0	0	15
2	14	1	1	14
3	13	2	2	13
4	12	3	3	12
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
16	0	15	15	0
17	0	15	15	0
18	1	14	14	1
19	2	13	13	2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
32	15	0	0	15

The caption "Series A" is used to designate the first series learned on any particular day. "Series B" refers to the second series of the same day. The total, as given above, we arbitrarily call a *cycle* of experiment days. Four results are obtained for any definite position in the variant interval, *e.g.,* take rest four and work twelve; this combination occurs four times in the cycle. It will be noted that this cyclic arrangement presents the following advantages:

1. The effect of any practice is fairly equally distributed. Thus it will be seen that the number of days' practice preceding any position in the variant interval is 31. *E.g.,* suppose we take rest 12, work 3. The days preceding the first result are three, those preceding the last result are twenty-eight.

2. The effect of fatigue is balanced. Any criticism that the B series had the disadvantage, because of the learning and test of the preceding A series, is evaded, at least as far as the comparative value of the results is concerned. In a complete cycle any position in the variant interval has occurred twice in the A and twice in the B series.

During that part of the variant interval not taken up with work, the subject sat quietly, having been instructed not to engage in any particular mental activity, but to rest as completely as possible. The work used in this experiment during the variant interval was cross-multiplication, the multiplicand and the multiplier each consisting of three figures. The process may be best given by an example. Take 736 x 284; the process is as follows:

$$
\begin{array}{ll}
4 \times 6 & = 24 \\
4 \times 3 + 8 \times 6 + 2 & = 62 \\
4 \times 7 + 2 \times 6 + 8 \times 3 + 6 & = 70 \\
8 \times 7 + 3 \times 2 + 7 & = 69 \\
2 \times 7 + 6 & = 20
\end{array}
$$

Hence the answer is 209024.

The subject is required to work all these steps mentally, *i.e.,* without recourse to notes, jotting down the figures "to carry," or similar aids.

The test follows immediately upon the variant interval. Between the closing of the test of the A series and the beginning

of the learning of the B series, there occurs, as noted before, an interval of at least five minutes, during which introspections and remarks of the subject are recorded. During this interval the subject is allowed to talk freely with the operator, walk about the room, etc., but is forbidden to do any thing that will act as an unusual excitant.

The subject used in this experiment was B. He was experienced in learning nonsense syllables, having acted as a subject in the preliminary experiments leading up to this work. He was exceptionally good at remembering nonsense syllables, if allowed to form sense associations between them when learning. This was noted in the preliminary experiments, and he was instructed not to form such associations. We may say that, at the beginning of the present experiment, his habit of forming such sense associations was fairly well broken.

The results of this experiment may be seen from the following curves, Fig. 2.

A and B are success curves. C is the time curve corresponding

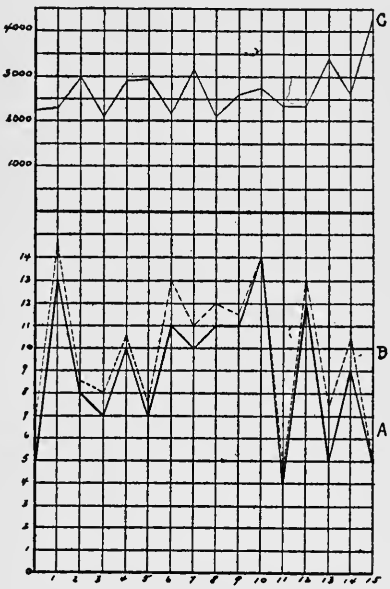


FIG. 2

to curve A. In all three curves the abscissae represent the number of minutes of the variant interval employed in mental activity. As the abscissae increase the work gradually fills the variant interval from the end backwards. *E.g.,* under abscissa 6 the experiments would be disposed; learning, rest nine minutes, work six minutes, and test. In curve A the ordinates represent the number of wholly correct responses obtained for the different abscissae. In B the ordinates represent the wholly correct responses plus the partially correct responses (two letters correct being the only ones considered), each of these latter evaluated at one-half—and not two-thirds—of a wholly correct response. In curve C the ordinates represent the average time, in sigmata, of the wholly correct responses corresponding to the different abscissae.

There were a few correct responses for which the operator, through his fault or some defect in the apparatus, failed to get accurate time. Consequently, in the computation of the time curve of the present experiment, as well as of those of subsequent experiments, any ordinate represents the average time for the wholly correct responses for which time was received.

The greatest number of successes was obtained with rest 5, work 10; the least number with rest 4, work 11—two adjacent points. Their separation along the Y axis, is greater than that between any other two points of the curve. One is hardly convinced of the validity of such a disparity existing between adjacent points. No essential difference between such points would be expected. To be sure, we should not attempt to draw too much from this experiment, because of the small number of results for each position in the variant interval. If we consider the success curve as a whole, we note that the general trend is slightly upward to point 10, from point 10 the general trend is slightly downward.

Curve B shows no particular value over curve A. Even with so few results, the nature of the two curves is not essentially different. With increasing numbers for the different ordinates, it appears that the character of the two curves would be less different. Consequently, it scarcely seems necessary, at least

for our main purpose, to consider the partial responses in the computation of the success curve.

If we consider the time curve, we note, starting with point 10, a general tendency upwards. Other than this the time curve shows no particularly clear relation to the success curve.

No elaborate introspections were taken in this experiment. It may be well to state that the subject repeatedly indicated that the influence of the interpolated work was not noticed, asserting, that if he had a syllable, he had it, and the work had no noticeable effect.

Relative to the maximum and minimum points of the success curve, it may be remarked that, under rest 4, work 11, one set of syllables, erroneously constructed, was given. The set yielded three correct responses. The other series of the day, with rest 11, work 4, yielded no correct responses. It would seem that if the erroneous construction—disobedience of restriction No. 5—had any influence, it favored the correct responses. If we allow for this, it would mean still greater disparity between abscissae 10 and 11, in that abscissa 11 would be still lower. On another day, with similar experimental conditions, save that the order of the variant interval was, in the A series, rest 11, work 4, and in the B series, rest 4, work 11; the former gave three correct responses, while the latter yielded none. The subject reported that he thought the result, in the latter case, was due, not to the work introduced, but to the difficulty of the series of syllables. If we consider it valid to allow for this, the height of abscissa 11 would be raised. We may balance this allowance against the previous tendency.

We present below a table giving in outline the setting and results of the different experiment days that are included under Experiment I.

TABLE I

E.D.	R.	W.	A. Series S3	A. Series S2	A. Series S1	B. Series S3	B. Series S2	B. Series S1	R.	W.
1	15	0	1	2					0	15
2	14	1	2	1	1	3	1		1	14
3	13	2					2		2	13
4	12	3	1	2	2	3		1	3	12
5	11	5	3	1				1	4	11
6	10	5	2		2	1			5	10
7	9	6	2	1		3			6	9
8	8	7			1	2			7	8
9	7	8	4			4	1	1	8	7
10	6	9	1	1		1	1		9	6
11	5	10	3			1		1	10	5
12	4	11	3	1	1				11	4
13	3	12	2	1		1			12	3
14	2	13				4	1		13	2
15	1	14	1	1		1			14	1
16	0	15	1			2			15	0
17	0	15	3			1		1	15	0
18	1	14	2	1		3	2		14	1
19	2	13	1	1		2			13	2
20	3	12	4			2			12	3
21	4	11	1		1	4		1	11	4
22	5	10	3			3	1		10	5
23	6	10	2			6	1		10	6
24	7	8	2	1		3	1		8	7
25	8	7	3			3	1		7	8
26	9	6	2	1		5			6	9
27	10	5	1			7			5	10
28	11	4	3					1	4	11
29	12	3	3		1	3	1		3	12
30	13	2	2		1	4	2	1	2	13
31	14	1	7			3			1	14
32	15	0	1	2		1			0	15
	Totals		66	17	10	76	15	8		

Under E. D. we have the temporal order of any particular experiment day. R. and W. refer to the composition of the variant interval, following the A or B series, as the case may be. Under R. we have the number of minutes rest immediately following the learning of the A (or B) series before any work is engaged in. The number of minutes work employed is found under W. In the columns S_3, S_2, S_1, appears the absolute number of correct, partially correct (two letters of a syllable), and partially correct (one letter of a syllable), responses respectively. R. plus W. should, in every case, equal fifteen minutes, since fifteen minutes was taken for the length of the variant interval in the experiment. However, there are three instances in which this was not the case. In neither case does the additional minute

change the setting until after nine minutes after the learning of the syllables. The writer considers the point negligible. But, even if not so, the results of the particular day involved weight against (to anticipate) the general conclusion of this paper.

By referring to the table, we may compare the total successes of the A series with the total successes of the B series. We find for the A series, $\Sigma S_3 = 66$, $\Sigma S_2 = 17$, $\Sigma S_1 = 10$; for the B series, $\Sigma S_3 = 76$, $\Sigma S_2 = 15$, $\Sigma S_1 = 8$. The advantage in favor of the B series is a trifle greater than we should expect chance to give either series. Due to the mental activity connected with the A series, we may assume a slightly fatigued condition of the subject at the beginning of the learning of the B series. Hence, we should have expected the A, instead of the B, series to possess any slight advantage.

Of the thirty-two partially correct responses (two letters correct), twenty-two were of the Di- type, *i.e.,* the initial consonant and the vowel correct; seven were of the -it type, *i.e.,* the vowel and final consonant correct; while only three were of the D-t type, the initial and final consonants correct. This was to be expected since chance, in a combination of two letters, one of which is a vowel, favors a consonant and a vowel rather than two consonants. Further, we may explain the advantage of the Di- type over the -it type in accordance with the laws of association. Clearly, when the measure Loc Dit is learned, the association between Loc and Di is much stronger than that between Loc and it.

Of the eighteen cases of partial responses (one letter correct), ten of these letters were vowels, and eight were consonants. Of the eight consonants, four were initial and four were final. Here again we should expect the vowels, relatively, to have the advantage, since the number of vowels to select from is only one-fourth (approximately) as large as that of the consonants. The smallness of the number of each probably renders the results more or less meaningless.

A distribution of the total number of correct responses received, according to the position which they occupied in the learning, shows the following:

Position	No. of Successes
1	19
2	20
3	18
4	18
5	20
6	21
7	26

A further discussion of the point here involved will be deferred until later.

Experiment II

The subject for this experiment was F. The experiment continued sixty-four experiment days. Fourteen-syllable series were used. The velocity of exposure of the syllables was twenty-three and one-third seconds. The variant interval was fifteen minutes. The work used, cross-multiplication. In fact, the experiment is exactly similar to Experiment I, with two exceptions, (1) the present experiment was continued longer—to sixty-four days, instead of thirty-two; and (2) a different subject was used. Two complete cycles of results were obtained, giving eight results for each position in the variant interval. As nearly as possible, the same hour of the day on different experiment days was used. A curve plotted from the results of the experiment follows in Figure 3.

In curve A the abscissae represent the number of minutes worked for the different positions in the variant interval. The ordinates represent the total number of successes for any position. In curve B the abscissae are the same as in curve A. The ordinates, however, represent the values of curve A plus the partial successes. Only those responses with two letters correct, of the three of a syllable, are considered, and each one of these is valued at one-half the value of a successful response. The time curve is shown by curve C. Abscissae as in A and B. The ordinates represent the average time of the correct responses for any position in the variant interval.

The following points may be noted:

1. The lowest point of the success curve occurs with rest 1, work 14. The highest point occurs with the position rest

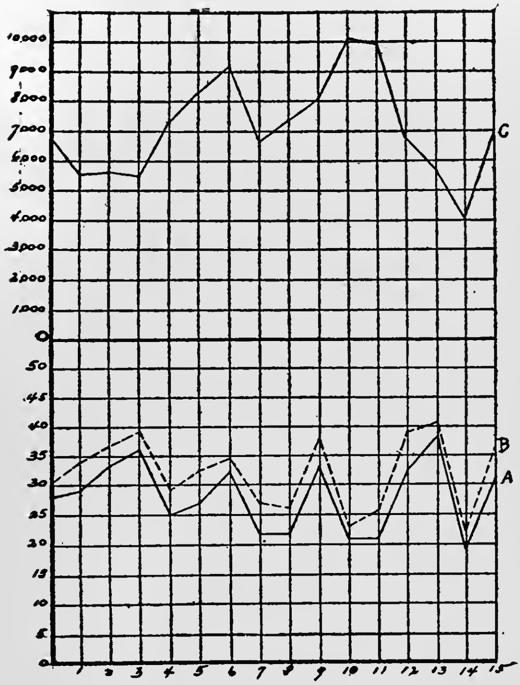


Fig. 3

2, work 13. These two points are adjacent, and it is hard to account for such a difference existing between two points whose position would seem, naturally, to merit no such distinction. We noted a similar occurrence in Experiment I, only in that experiment the divergent points were 11 and 12 instead of, as in the present experiment, 13 and 14.

2. To the lowest point of the success curve corresponds the lowest point of the time curve, but to the two next lowest points of the success curve correspond the two highest points of the time curve—two results that do not seemingly harmonize with themselves, and with what we might have expected. It would seem reasonable to suppose, from our general idea of retroactive inhibition, that with a large number of successes would correspond short times. But this is not the case in our curves. In fact, there seems to be no simple expressible relation between the

two curves. According to the results of Müller and Pilzecker this relation is an inverse one.

3. The undulatory character of the success curve, noticeable also in the success curve of Experiment I, is no less surprising than bewildering.

The writer wishes to call attention to the fact that the subject used in this experiment had had considerable experience in learning nonsense syllables previous to this experiment. Again, he did not have such a tendency to form sense associations as was the case with the subject in Experiment I. It may be well to mention here that subject F. and subject B. were quite different in temperament; subject F. being calm, deliberate, slow and easy going; while subject B. was quite the opposite, quick, active and alert.

Here, as in Experiment I, a large number of introspections is wanting. The subject reported no noticeable effect of the interpolated work. He reported that he though the process of multiplication tended to become a mechanical one, not requiring the closest attention. He had at one time held a clerical position requiring the constant use of figures. His idea was that such work may become automatic, columns of figures may be added while the attention is directed elsewhere. The writer has acted as subject where cross multiplication was used; he is also accustomed to the frequent use of figures in clerical work. With him the process in the cases cited seems to be far removed from the mechanical. To be sure, after a little practice, the work can be done with greater rapidity; the figures seem to fall into line, as it were; the result seems to come forthwith, but most successfully, only when the attention is closely given to the work in hand.[1]

A table follows showing the setting and results of each day's experiment:

[1] *Cf.* Ladd and Woodworth's position relative to habitual actions, *Elements of Physiological Psychology*, 1911, p. 564.

TABLE II—A Series

E.D.	D--	Di-	-i-	-it	--t	D-t	R.	W.	S_3	S_2	S_1
1		1					15	0	3	1	
2		1	1				14	1	5	1	1
3			1		1		13	2	3		2
4		1	1				12	3	5	1	1
5		2			1	1	11	4	1	3	1
6		1		1			10	5	2	2	
7		1	1				9	6	3	1	1
8		1	1				8	7	3	1	1
9		1					7	8	3	1	
10		1					6	9	4	1	
11			1				5	10	2		1
12			1	1			4	11	2	1	1
13		3				1	3	12	3	4	
14		1					2	13	5	1	
15						1	1	14		1	
16							0	15	4		
17		1		1			0	15	5	2	
18		1		1			1	14	3	2	1
19				1			2	13	5	1	
20		1		1			3	12	5	2	
21				1			4	11	4	1	
22			1	1			5	10	2	1	1
23		2	1		1		6	9	1	2	2
24		1					7	8	6	1	
25			1	1			8	7	3	1	1
26			1				9	6	4		1
27				1			10	5	5	1	
28					1		11	4	5		1
29							12	3	7		
30							13	2	5		
31		1	1				14	1	4	1	1
32			1			1	15	0	4	1	1
33	1		1				0	15	4		2
34		1					14	1	6	1	
35		2	1				13	2	4	2	1
36			2	1			11	4	4	1	2
37		2					12	3	5	2	
38	1						10	5	4		1
39				1	1		9	6	4	1	1
40				1		1	8	7	2	2	
41							7	8	4		
42							6	9	6		
43		1	2				5	10	1	1	2
44			1		1		4	11	2		2
45				1			3	12	4	1	
46	1					1	2	13	4	1	1
47			1				1	14			1
48				1			0	15	5	1	
49			2	1			15	0	3	1	2
50		1					1	14	5	1	
51		1					2	13	6	1	
52		1					3	12	5	1	
53						1	4	11	4	1	
54			1				5	10	4		1
55							6	9	5		
56		1	2				7	8	1	1	2
57		2	1	1			8	7	1	3	1
58		1					9	6	6	1	
59		1		1			10	5	3	2	
60		2					11	4	3	2	
61				1			12	3	4	1	
62				1		1	13	2	4	2	
63		1	1				14	1	4	1	1
64							15		6		
	3	38	28	20	6	8			239	66	38

TABLE II—B Series

E.D.	S_3	S_2	S_1	R.	W.	D- -	Di-	-i-	-it	- -t	D-t
1	2	2	1	0	15		1		1	1	
2	4			1	14						
3	3	1	1	2	13		1	1			
4	1	5	1	3	12		2	1	3		
5	2	1	2	4	11		1	2			
6	1	1	2	5	10	1		1	1		
7	3	2		6	9		2				
8	2	1	1	9	6	1	1				
9			3	8	7			1		2	
10	1	1	1	7	8		1	1			
11	3	2		10	5		2				
12	2	1	1	11	4	1	1				
13	2	1		12	3		1				
14	1		3	13	2			3			
15	1	2		14	1		2				
16	3	1		15	0		1				
17	1		5	15	0	2		3			
18	3	1	1	14	1		1	1			
19	4	2	1	13	2			1	2		
20	7			12	3						
21	1	1	2	11	4		1	1		1	
22	1	2		10	5		2				
23	3	1	1	9	6		1	1			
24	6	1		8	7		1				
25	3	2		7	8				1		1
26	6			6	9						
27	6			5	10						
28	3	2		4	11		2				
29	5	1		3	12		1				
30	5		1	2	13			1			
31	1	2	2	1	14		1			2	1
32	4		2	0	15			2			
33	5		2	15	0			2			
34	3	1	1	1	14		1	1			
35	7			2	13						
36	2	1	3	4	11	2	1	1			
37	5			3	12						
38	1	1	3	5	10			3	1		
39	4			6	9						
40		2	4	7	8			4	2		
41	4		1	8	7			1			
42	4		1	9	6					1	
43	4	1		10	5				1		
44	5		1	11	4			1			
45	2		1	12	3	1					
46	5	1		13	2						1
47	4	1		14	1				1		
48	3	1		15	0		1				
49	3	3	1	0	15		1	1	2		
50	2	2	1	14	1	1	1		1		
51	7			13	2						
52	4	1	1	12	3	1	1				
53	4	1	1	11	4		1	1			
54	5	1	1	10	5			1	1		
55	6			9	6						
56	3	2	1	8	7		2	1			
57	4		3	7	8			2		1	
58	4	2		6	9		2				
59	4			5	10						
60	2	2		4	11		1				1
61	4		1	3	12			1			
62	3		1	2	13	1					
63	3		3	1	14			3			
64	4	2		0	15		2				
	210	61	62			11	40	43	17	8	4

The significance of the different abbreviations is fully explained under Table I, Experiment I, page 20.

A point, scarcely worthy of note, is that the temporal order of the experiments on the eighth, ninth, and tenth days, is the reverse of our plan. The same occurs with days 36 and 37. The A and B series of days 33 and 49 are the reverse of the planned order. Both days, however, correspond in setting, hence the reversal of one practically equalizes the reversal of the other.

In our present results, of the total successes for the A and B series, we note quite the opposite to that received in Experiment I. The A series gives, on the whole, $\Sigma S_3=239$, $\Sigma S_2=66$, $\Sigma S_1=38$; while the B series gives $\Sigma S_3=210$, $\Sigma S_2=61$, $\Sigma S_1=62$. We may explain our present result in accordance with our previous reasoning, (p. 21), that the second set of the day may be at a slight disadvantage. This, together with chance variation, we may say, gives rise to the difference existing between ΣS_3 of A and ΣS_3 of B.

We wish to mention another point, the details of which are not presented. If we proportion the total 449 (ΣS_3 (A) plus $\Sigma_3 S$ (B)) correct responses according to their temporal order, as respects measures, in the learning, we obtain:

Position	Responses
1	74
2	51
3	60
4	62
5	66
6	63
7	72

It was very noticeable with subject F. that he often knew the position a syllable occupied in the learning when he could not recall that syllable. It is to be remembered that the order of the syllables in the test was not the same as that in the learning, and the order for the test of the A series was not the same as that for the B series.

The subject remarked that the syllable learned first often fails to come up in the recall. We could attribute this to an assurance at the first causing a comparative lack of attention to that syllable in the latter part of the learning process. The subject also noted

that he thought the getting of the response to the first test syllable had a particular influence upon the total successes of that trial. His idea being, *caeteris paribus,* a successful response to the first test syllable initiates a kind of systematic preparation for the responses to the remaining test syllables. Theoretically, this appears plausible; if we assume the subject has a certain stock of correct responses, consciously or unconsciously, at the beginning of the test, the precipitation of any one of them may prepare the remaining and lend a certain amount of impetus, due to the feeling tone connected with the successful response. This effect, coming at the beginning, is much more potent, since the succeeding test syllables are unimpaired by any unsuccessful inhibiting attitude, which is necessarily the case when the first or first and second responses are unsuccessful.

The subject's idea of how he gets the correct responses may be instructive. They are due to one, or some combination of, the three factors, (1) direct association, (2) getting the position occupied by the syllable in the learning, and (3) running over the stock of syllables on hand. Towards the end of the experiment the subject indicated that there was much more to learning a set of syllables than the mere allowing them to pass before the field of vision, framing his view, "Some force is let loose that feels like an original will-power"; meaning probably nothing more than a concentration of attention, or, as expressed by Ladd and Woodworth[2] "setting up a favorable adjustment."

Experiment III

The two previous experiments have partially indicated the difficulty of our task. It is to be remembered that the present work was intended to be an elaboration of the work done by Müller and Pilzecker on rectroactive inhibition. Consequently, we assumed their work as a base. Neither our preliminary experiments nor the two experiments given above, showed any evidence that we were going to receive any such "striking" results as those received by the German investigators. Naturally, it appeared necessary to conduct experiments, similar to the ones

[2] *Elements of Physiological Psychology,* 1911, p. 582.

carried out by them, for the purpose of confirming their results, or establishing new ones.

The general method of this experiment was similar to that of Experiments I and II, but different from them in that, in our present experiment, only two points of the variant interval are under investigation. On each experiment day two series—an A and a B—of seven measures, two syllables to the measure, were learned. Ten repetitions were used for each series. Subject B., the same as in Experiment I. Following the learning of one series, there was a rest period of fifteen minutes, then the test. Immediately following the learning of the other series, the subject engaged in cross multiplication for ten minutes. A rest period of five minutes followed the multiplication, then the test was made. On one day the multiplication was placed in the A series, on the next day it was placed in the B series. This gives us an equal distribution between the A and B series of the deleterious effect of any fatigue, arising from having learned a previous set of syllables. Of course, even then, the objection lies open that, from the standpoint of fatigue, the set with work following has a slight advantage in that, when it occupies the second position (B series), no work was done during the preceding variant interval. When the set, with no work following, occupied the second position, ten minutes of work were engaged in during the variant interval of the first set.

The experiment extended over a period of 16 experiment days with the following results, $n = 112$:

TABLE III

	S_3	r	m.v.	%	S_2	S_1	T_r	$T<2000\sigma$	$T<1500\sigma$
Cs. I. Rest 15	54	3.4	1.6	48	5	4	2221	31	22
Cs. II. Work 10, Rest 5	37	2.3	1.0	33	4	4	2673	15	9

The above table gives the absolute number of successes, S_3; the average number in a set, r; the per centum, %; the mean variation, m.v.; the number of syllables, two letters correct, S_2; the number of syllables, one letter correct, S_1; the average time for the correct responses, T_r; the absolute number of correct responses with time less than 2000 sigmata, $T < 2000\sigma$; and the number with time less than 1,500 sigmata, $T < 1500\sigma$.

The results obtained in this experiment seem to favor the assumption that retroactive inhibition plays a part under such conditions as those of Case II. However, the force of these results becomes somewhat weakened, when viewed in connection with those received in the next experiment with the same subject.

Experiment IV

The present experiment extended over a period of ten experiment days. Subject, B. Seven-measure nonsense syllables were repeated ten times. The variant interval of fifteen minutes was thus disposed. On each experiment day two series were learned. Immediately following one series there elapsed a rest period of six minutes, the remaining nine minutes were occupied in cross-multiplication. Following the other set there elapsed a rest period of two minutes, then thirteen minutes of cross-multiplication. At the close of the variant interval, the syllables were tested. A rest period of at least five minutes occurred between the test of the first and the learning of the second series on any experiment day. On one experiment day the variant interval, containing the rest six minutes, work nine minutes, followed the learning of the A series; on the next day it followed the learning of the B series. The results follow in Table IV, $n = 70$:

TABLE IV

	S_3	r	m.v.	%	S_2	S_1	T_r	$T<2000\sigma$
Cs. I. Rest 6, Work 9....	20	2	1	29	3	2	2675	14
Cs. II. Rest 2, Work 13....	26	2.6	1.6	37	2	0	3328	11

Above is given, in tabular form, the absolute number of successes, S_3; the average number, r; the mean variation, m. v.; the per centum, %; the number of syllables, two letters correct, S_2; the number of syllables, one letter correct, S_1; the average time for the correct responses, T_r; and the absolute number of correct responses with time less than 2000 sigmata, $T < 2000\sigma$.

Attention may be called to the fact that Case II, though its variant interval contains more work, and given sooner after learning, than Case I, gives more successful responses. The

average time for Case II is longer than that for Case I. There appears no evident reason for the getting of more successes in Case II. The suggestion offers itself that the greater mental activity of Case II placed the subject in a condition of better mental preparedness for the test than did Case I. Assuming the activity of retroactive inhibition, the time result is what we should expect.

The results of this experiment suggest that two minutes after the learning of a series, retroactive inhibition plays no noticeable part in diminishing the number of successful responses, though it may appear in a slight retardation of the correct responses. The author realizes that the meagreness of numbers, if we consider in isolation the experiment at hand, is a serious drawback to final acceptance of any apparent conclusions therefrom.

Experiment V

This experiment was conducted exactly as Experiment IV, save with a different subject, subject D., and with an essential change with respect to the variant interval. In the present experiment, the variant interval of fifteen minutes was thus occupied; the subject either cross-multiplied the full time, beginning immediately after learning, or he rested the full time. On one day the cross-multiplication came after the A series, on the next day it came after the B series. The subject was an experienced one in learning nonsense syllables. He tended rather toward the steady, slow, deliberate temperament. The experiment continued for ten experiment days, with the following results; Table V, n = 70:

TABLE V

	S_3	r	m.v.	%	S_2	S_1	T_r	$T<2000\sigma$
Cs. I. Rest 15	24	2.4	.96	34	4	9	5149	6
Cs. II. Work 15	21	2.1	1.31	30	5	5	5822	2

The column symbols have exactly the same meaning as those used in Experiments III and IV, p. 29f.

Case I shows a slight advantage over Case II, with respect to the number of successful responses. A *slight* advantage is

all that can be claimed; even that—it is not unreasonable to assume—may have been due to mere chance. To be sure, the argument works both ways equally well; it may be claimed that chance favored the results of Case II.

Surely, if we are to obtain a retroactive effect, it should have appeared in Case II, with fifteen minutes work immediately subsequent upon the learning. Shall we then tend towards some such conclusion as the non-existence of retroactive inhibition? Or, shall we refrain—doubtless the better way—on account of the paucity of results, from drawing any general conclusions, until the question is more fully investigated? It seems that we may be allowed to question the importance of the part retroactive inhibition has hitherto been assumed to play in influencing the recall of nonsense syllables.

Experiment VI

The plan of this experiment was the same as that pursued in the preceding experiment, save that in this a different subject, subject W., was used, one who had not had very much experience in learning nonsense syllables. Ten repetitions were given each set of seven-measure syllables. The variant intervals were of two kinds, one where the subject rested the full fifteen minutes; the other where immediately after the learning, the subject worked at cross-multiplication for ten minutes, and then rested the remaining five minutes. The test followed the variant interval. The experiment continued nine experiment days. The results obtained are given below in Table VI, $n = 63$:

TABLE VI

	S_3	r	m.v.	%	S_2	S_1	T_r	$T < 2000\sigma$
Cs. I. Rest 15	50	5.6	1.2	79	5	0	2828	18
Cs. II. Work 10, Rest 5	43	4.8	1.3	68	2	1	2955	12

The symbols at the head of the different columns have been fully explained. See above under Experiments III and IV, p. 29f.

We note here an advantage in favor of Case I, in respect both to the number of correct responses, and the celerity of the response. The advantage, however, is not a decided one; especially is this the case with respect to time. It is noticeable that Case I

shows more correct responses with reaction time less than 2000 sigmata. The advantage in favor of Case I, on the part of the successful responses, seems too large to be wholly accounted for on the basis of variation and chance.

Experiment VII

W. acted as subject for the present experiment. The only essential difference between the setting of this experiment and that of Experiment VI, lies in the fact, that, in the learning, the syllables were presented auditorially instead of visually. This was accomplished by reading the syllables to the subject. Six repetitions were given each series. The metronome was set at 72. The operator began a measure on one stroke of the metronome and ended on the next; two strokes were allowed for rest; then a new measure was read. For the test additional apparatus was used, a second mouth-key, a lamp battery and a relay. It will be recalled that the mouth-key is fitted with tambour and metal pointer for breaking a circuit only. With the use of two circuit breakers alone, the use of the chronoscope is impractical either with open or closed circuit. The difficulty is obviated by the use of the lamp battery and the relay apparatus. The set-up may be shown diagrammatically as follows, Fig. 4:

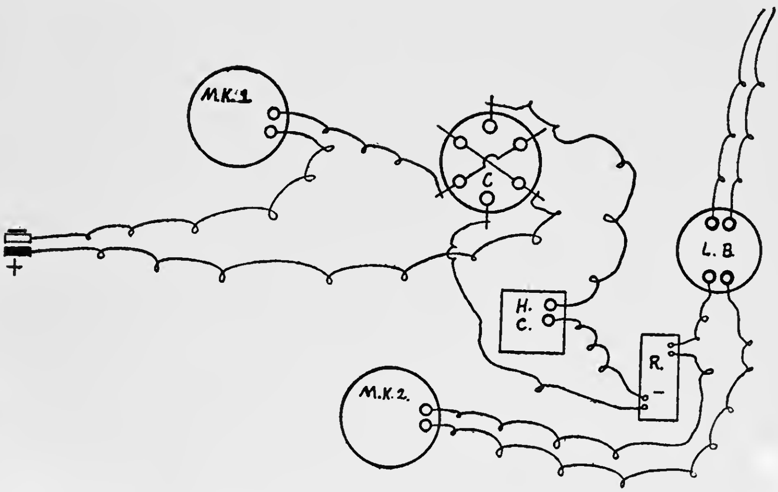


Fig. 4

M. K. 1, mouth-key for the subject; C., commutator; L. B., lamp battery; H. C., Hipp chronoscope; R., relay; and M. K. 2, mouth-key for the operator.

The complete apparatus was used only in the test. The purpose of the lamp battery and relay was to give a closed circuit through the chronoscope, when the operator spoke the test syllable into M. K. 2. The subject's response was spoken into M. K. 1. A rubber tube led out from M. K. 2 to the subject's ear. The subject's end of the tube was fitted with a common phonographic listening device. This device consists of a concavo-convex disk (diam. 5 cm.) of wood, through the centre of which runs a short piece of tin tubing.

The experiment continued ten experiment days with the following results, Table VII, n = 70:

TABLE VII

	S_3	r	m.v.	%	S_2	S_1	T_r	$T<2000\sigma$	$T<3000$
Cs. I. Rest 15	28	2.9	1.1	41	11	6	5127	7	11
Cs. II. Work 10, Rest 5..	28	2.8	0.7	40	15	4	4286	4	11

The meaning of the headings of the different columns is fully explained under Experiments III and IV, p. 29f., save that we have added a column, $T < 3000\sigma$, which includes the absolute number of successes with time less than 3000 sigmata. It should be mentioned that the measure of correctness of a response consisted in its agreement with the correct syllable in sound, and not in spelling, as in the case of those syllables given visually.

We note here, with respect to the number of successful responses, practically no particular advantage shown by either case. An exceptional result occurs in that the average time for the correct responses of Case II is less than that for the correct responses of Case I. In our previous experiments, the average time for Case II has always been greater than that for Case I. Case I shows an advantage in the number of very short times, less than 2000 sigmata, seven as compared with four for Case I, but when 3000 sigmata is the maximum time for comparison, both cases yield the same number of times less than that amount.

Experiment VIII

The general method of this experiment was the same as that used in Experiment VI. D. acted as subject; fourteen-syllable nonsense series were used. Two sets were learned on each day. A variant interval of sixteen minutes was thus disposed: Instead of using cross-multiplication as interpolated work, as in the previous experiments, physical work was employed. The subject was harnessed to an ergograph, so that the weight would be lifted from the shoulders. The lifts were made with the metronome, one every two seconds. Immediately after the learning of one set of syllables, one minute was taken for adjustment of the apparatus to the subject, then came ten minutes work with the ergograph, followed by a rest of five minutes, then the test. In a second case no work followed the learning of a series of syllables. On one day the work came in the A series, on the next day it came in the B series. The experiment continued nine experiment days, giving the following results, Table VIII, $n = 63$:

TABLE VIII

		S_3	r	m.v.	%	S_2	S_1	Tr	$T < 2000\sigma$	$T < 3000\sigma$
Cs. I. Rest 16	42	4.7	1.2	67	4	4	4862	13	19
Cs. II. Adj. 1, Erg. 10, Rest 5	27	3.0	0.9	43	2	2	4108	8	14

For explanation of symbols used see Experiments III, IV and VII.

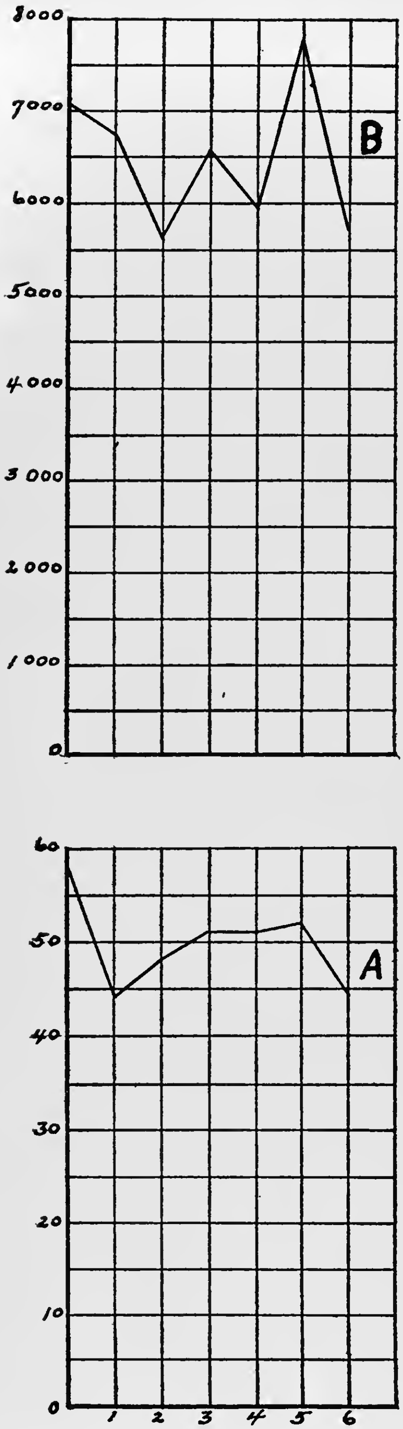
Here we have quite an advantage in favor of Case I. The number of successes afforded by Case II is open to the very serious objection that its smallness may be due to physical fatigue rather than retroactive inhibition. The difference is quite explainable upon the basis that, at the time of the test, the lingering fatigue sensations, together with the associated complex of "sensations of rest," prevented complete attention to the recall of the learned nonsense syllables. This, it appears to the writer, is a sufficient explanation of the existing difference, without necessitating the employment of a shock effect of the physical work upon the learned syllables. In case the shock effect existed, the present experiment was not adequately designed to differentiate it from the fatigue effect.

Experiment IX (a)

Hitherto, in our discussion, we have been hampered and forced to refrain from any final conclusions because of the paucity of numbers. Hence it was desired to conduct an experiment to such length that the weight of numbers should not be wanting. It was the experimenter's purpose, in the present experiment, to meet such a requirement. In order that the work might not become too laborious, and extend to too great length, fewer points of the variant interval were taken for investigation than were taken in Experiments I and II, whose general plan the present experiment follows. The length of the variant interval was fifteen minutes. The first six minutes of the variant interval were the only ones subjected to variance, the other nine minutes serving as a rest period previous to the test. In justification of so narrowly restricting the variant part, we may cite experiments I to VII. From them the only conclusion relative to retroactive inhibition, we wish to urge, is that mental activity, following three or four minutes after the learning of a set of nonsense syllables, produces no apparent retroactive effect upon the number of successful responses in the recall. Consequently, we consider the limits of the variant factor in the present experiment as sufficient, and deem more extended limits unnecessary in the investigation of the factor under consideration.

Seven measures, two syllables to the measure, were repeated ten times by the subject. The first six minutes following the learning were disposed in accordance with the day's position in the cyclic order. In consequence of the length of the variant part of the variant interval, the cycle, which is fully explained *supra*, (p. 15f.), consists of fourteen experiment days. Following the variant interval of fifteen minutes came the test. Here the experiment days follow fairly closely the calendar days. In all instances the work is carried out in the afternoon, and for the most part at the same hour of the day.

Z. B. served as subject. The experiment continued seventy days, thus completing five cycles, and giving twenty different results for each point in the variant part of the variant interval. A success curve, A, and a time curve, B, plotted from the results, follow in Figure 5, n = 140:



8000
7000
6000
5000
4000
3 000
2 000
1 000
0
B
60
50
40
30
20
10
0
A
1
2
3
4
5
6

Fig. 5

A is a curve representing the total successes. B represents the time curve. In A and B the abscissae represent the number of minutes in which mental activity (cross-multiplication) was employed in the variant part of the variant interval; *e. g.*, abscissa 4 corresponds to the day's arrangement, learning, rest two minutes, work four minutes, rest nine minutes, and test. In A the ordinates represent the relative number of successful responses. In B the ordinates represent the average time of the successful responses.

A subsidiary curve, plotted in accordance with the method used in plotting Curve B, Fig. 2, p. 17f. and Curve B. Fig. 3, p. 22f., shows no essential difference from our present Curve A, the courses of the two curves always running in the same direction. Consequently this curve has been omitted.

The highest ordinate of the success curve occurs under abscissa 0, where no work occurred in the variant interval. A seemingly non-harmonizing result occurs in that abscissa 1 vies with abscissa 6 for the lowest point of the curve. In order to consider the results more in detail two tables, Table IX and Table X, are subjoined.

TABLE IX

Minutes Worked

0			1			2			3			4			5			6		
S_3	S_2	S_1	S_3	S_2	S_1	S_3	S_2	S_1	S_3	S_2	S_1	S_3	S_2	S_1	S_3	S_2	S_1	S_3	S_2	S_1
4		1	3			3	1	1	4			1	1	1	4		1	3	1	1
6				1	1	2				1	2	3			4			3	1	
1	1	1	3			1	1		2			3	1	1	2		1		1	1
		2	2			3			1		1	3		1	1	1		1	1	
11	1	4	8	1	1	9	2	1	7	1	3	10	2	3	11	1	2	7	4	2
2	2	1	3			1		1	2	2			2			2	2	2	1	1
1		1	2		1	3		1	1	2	1	3		1	1	1	1	2	1	2
3				1	1	1	2		3		2	3			2		2	3		1
1		2	3			2		3	6	1			2	2	3	1		4		
18	3	8	16	2	3	16	4	6	19	6	6	16	6	6	17	5	7	18	6	6
4		2	2	1		1			2	1						1			1	1
3	1		2		1	1			2	2	1	1		4	4	1		1		2
				2	1	2	2		2	1	1	5			1		2		2	1
3		2	4			2	1		4	1		4			1	2	1	4		
28	4	12	24	5	5	22	7	6	29	11	8	26	6	10	23	9	10	23	9	10
4	1		4		1	2	2		3		1	4		1	3			1		1
3			3		2	2	2		4			3			2		1	5		
3	1		3			4			1		1	5			6			3		
3	2		1			3		1	4	2		2	2		2	2		2	1	3
41	8	12	35	5	8	33	11	7	41	13	10	40	8	11	36	11	11	34	10	14
6		1	4		1	3			1	1	1	4			4	1	1	2		1
3			2			4		1	2		1	1			4		1	2		1
1		1				5			4		1	2			4		1	2		1
7			3			3	1	2	3	1	1	4			4		1	4	1	
58	8	14	44	5	9	48	12	10	51	15	14	51	8	11	52	12	15	44	11	17

The figures at the head of the different columns correspond to the different abscissae of the curves. Under S_3 appears the number of wholly correct responses; under S_2, responses with only two letters correct; and under S_1, responses with only one letter correct. The totals at the end of each cycle, give the total number of responses, under the different columns, up to that time, and not the totals of the immediate cycle under which they are placed. The writer's opinion is that more is to be gained from a consideration of this table than from a consideration of the Curve A.

We note that work 0, when compared with work 6, has the advantage all the way through, save in the second cycle, where the reverse is the case, giving at the end of the second cycle, where $n = 56$, the same number of successful responses to the credit of each. A point of great significance is that abscissa 0 did not gain its ascendency over all other points until in the fifth cycle. At the end of the second and third cycles, abscissa 3 was in the ascendency and maintained an equality at the end of the fourth cycle, losing out only in the fifth cycle. Abscissa 6 did not uniformly occupy the lowest position, in fact, never occupying the lowest position of all. At the end of the fourth cycle, $n = 112$, abscissae 6, 5, 2, and 1 were practically on an equal footing. These considerations seem to indicate that the ascendency given to abscissa 0 at the end of the fifth cycle is not unquestionable. In fact, the results of the fifth cycle seem to play an unnatural part, as respects both abscissae 0 and 6. In the light of the results of the first four cycles, its value as a determinant of the final figures, seems too great. Hence, the curve from the results at the end of the fifth cycle can not be taken, without question, as a finality, representing the true status of the matter.

Again, if we consider the part of Curve A on each side of its mid-abscissa, i.e. 3, we get the total number of successes of the half towards abscissa 0, and that towards abscissa 6, equalling 175½ and 172½ respectively—their difference being wholly insignificant. This is an important fact, highly indicative, that the true path of the curve is along the horizontal, and consequently arguing against any effect of retroactive inhibition.

For a consideration of further details, we append the second table, Table X:

TABLE X—A Series

E.D.	D--	Di-	-i-	-it	--t	D-t	R.	W.	S_3	S_2	S_1
1			1				6	0	4		1
2			1				1	5	4		1
3	1	1					4	2	3	1	1
4							3	3	4		
5							4	2	2		
6		1			1		5	1		1	1
7							6	0	6		
8		1			1		0	6		1	1
9			1				1	5	2		1
10	1	1					2	4	3	1	1
11							3	3	2		
12			1				2	4	3		1
13							5	1	2		
14		1					0	6	1	1	
15		2			1		6	0	2	2	1
16							5	1	3		
17					1		4	2	1		1
18		1		1			3	3	2	2	
19					1		2	4	3		1
20		1			1		1	5	1	1	1
21					2	1	0	6	2	1	2
22	1						0	6	3		1
23			2				1	5	2		2
24							2	4	3		
25			2				3	3	3		2
26			1		2		4	2	2		3
27							5	1	3		
28			1		1		6	0	1		2
29			1		1		6	0	4		2
30				1			5	1	2	1	
31							4	2	1		
32						1	3	3	2	1	
33	1		1		2		2	4	1		4
34		1					1	5	4	1	
35			2				0	6	1		2
36			1	1		1	0	6		2	1
37			2				1	5	1		2
38							2	4	5		
39		1	1				3	3	2	1	1
40			1		1		6	0	3		2
41				1			4	2	2	1	
42							5	1	4		
43		1					6	0	4	1	
44			1				5	1	4		1
45		2					4	2	2	2	
46			1				3	3	3		1
47							2	4	3		
48	1						1	5	2		1
49							0	6	5		
50							0	6	3		
51							1	5	6		
52							2	4	5		
53					1		3	3	1		1

TABLE X—A Series (continued)

E.D.	D--	Di-	-i-	-it	--t	D-t	R.	W.	S_3	S_2	S_1
54			1				4	2	3		1
55							5	1	1		
56		1				1	6	0	3	2	
57			1				6	0	6		1
58	1						5	1	4		1
59							4	2	3		
60		1			1		4	2	1	1	1
61							2	4	1		
62					1		1	5	4		1
63			1				0	6	2		1
64			1				0	6	2		1
65			1				1	5	4		1
66							2	4	2		
67			1				3	3	4		1
68		1	2				4	2	3	1	2
69							5	1	3		
70							6	0	7		
	6	17	29	4	18	4			190 55%	25	53

TABLE X—B Series

E.D.	S_3	S_2	S_1	R.	W.	D--	Di-	-i-	-it	--t	D-t
1	3	1	1	0	6	1			1		
2	3			5	1						
3	1	1	1	2	4			1	1		
4		1	2	3	3	1	1	1			
5	3			2	4						
6	4			1	5						
7	3	1		0	6		1				
8	1	1	1	6	0			1	1		
9	3			5	1						
10	1	1		4	2				1		
11	1		1	3	3			1			
12	3			4	2						
13	1	1		1	5		1				
14			2	6	0			2			
15	2	1	1	0	6		1	1			
16		2	2	1	5	1	2	1			
17		2		2	4		1				1
18	1	2	1	3	3		2	1			
19	3		1	4	2			1			
20	2		1	5	1			1			
21	1		1	6	0			1			
22	3			6	0						
23		1	1	5	1		1	1			
24	1	2		4	2		1		1		
25	6	1		3	3		1				
26		2	2	2	4	1	2	1			
27	3	1		1	5		1				
28	4			0	6						
29		1	1	0	6		1	1			
30		1		1	5		1				
31				2	4						
32	2	2	1	3	3		1	1	1		
33	1			4	2						
34	2		1	5	1			1			

TABLE X—B Series (continued)

E.D.	S_3	S_2	S_1	R.	W.	D--	Di-	-i-	-it	--t	D-t
35	3	1		6	0		1				
36				6	0						
37		2	1	5	1		1	1			1
38	2	2		4	2		2				
39	4	1		3	3		1				
40	4			0	6						
41	4			2	4						
42	1	2	1	1	5		2	1			
43	1		1	0	6	1					
44	3			1	5						
45	4		1	2	4			1			
46	4			3	3						
47	2	2		4	2		1		1		
48	3		2	5	1	1		1			
49	3			6	0						
50	3	1		6	0				1		
51	3			5	1						
52	4			4	2						
53	4	2		3	3		1		1		
54	2	2		2	4		1		1		
55	2	2		1	5		2				
56	2	1	3	0	6	1		2	1		
57	2		1	0	6			1			
58	4	1	1	1	5			1	1		
59	4			2	4						
60	2		1	3	3			1			
61	4		1	4	2	1					
62	2			5	1						
63	3			6	0						
64	1		1	6	0			1			
65				5	1						
66	5			4	2						
67	3	1	1	3	3		1	1			
68	4			2	4						
69	4	1		0	6		1				
70	4		1	1	0	1					
	158 45%	46	37			9	32	28	12	0	2

The meaning of the symbols used has been given under Experiment II. A few partial displacements appear in the cyclic order, but, due to the brevity of the cycle, this appears negligible. Under E. D. 60, it will be noted that R. 4, W. 2 has been reckoned as R. 3, W. 3. This appears permissible, since, had the additional minute of work been engaged in, the result could hardly have fallen lower in that particular instant. Even as it was, the result is below that of the B series with the same point on the same day.

ΣS_3 of the A series equals 190, while ΣS_3 of the B series equals only 162, the percentages being 54.6 and 45.4 respec-

tively. In explanation of this difference, we may refer to our discussion under Experiment I. We note here, as previously, that the Di- type of partial successes far outstrips the -it type, the former giving, *in toto,* 49; and the latter, 16. The D-t type is fairly negligible, giving, in all, only six occurrences. In the one-letter-correct syllables, the vowels far exceed either the initial or the final consonant; in fact, the vowel occurs oftener than both combined.

If we take the total number of successes, *i.e.,* $\Sigma S_3(A)$ plus $\Sigma S_3(B) = 348$, and consider them relatively to the position they occupied in the learning, we get the following distribution according to measures:

Position	Responses
1	58
2	40
3	48
4	45
5	49
6	44
7	64

These results seem to indicate, as those in Experiment II, that syllables occupying the first and seventh measures, are more firmly associated in the learning process. Further, the seventh position seems to possess this advantage to the greatest extent. The results of Experiment I do not accord upon this latter point. In explanation, it may be suggested that the beginning and end syllables have special attention called to them, in that they begin and end the series. But since the repetitions are continuous, and there is no break at the end of the seventh position different from that at the end of any other position, except, of course, at the closing of the learning process, this attentive distinction seems a rather meagre explanation for the disparity at hand. A second explanation offers itself. Regardless of the continuity of the learning process, the subject is nevertheless aware, as the repetitions continue, of the end and beginning of the series. Hence, a characteristic difference qualifying positions 7 and 1. Without mentioning the results, the subject of the present experiment was questioned about the consciousness of such a distinction. The reply was in the negative. A

knowledge of the position in the series occupied by a syllable, with Z. B., seemed to be much less than that possessed by subject F., in Experiment II. The second explanation seems valid in case of the results with subject F., but appears somewhat lacking in explanation of the greater difference obtained with Z. B., unless we assume that the same attentive distinction was present, but subliminal. Even at that, we should hardly expect the difference to be greater in the latter case. Subject B. of Experiment I does not show the characteristic under discussion with respect to the first position. He does show it in case of the seventh position. No reason for the difference in case of subject B. is forthcoming, unless we ascribe it to the insufficiency of numbers.

The learning process (Vorzeigen), used by Müller and Pilzecker,[1] for the most part, gave between the last and the first syllable of a series, a longer interval than occurred between any other two adjacent syllables. Such a procedure, we may assume, slightly accentuates the importance of the last and first syllables. Their Experiment 28 was conducted with no such distinguishing difference qualifying the last and first syllables. The order of the positions occupied by the syllables in the learning, in accordance with the largeness of the number of syllables obtained, was 5, 4, 3, 6, 2, 1.

If we turn to a consideration of the time curve, we find, as in Experiments I and II, no apparent general relation between the time and the success curves. In four instances there is concordance of direction, in two instances there is opposition. If we except the fifth abscissa, the general trend of the curve is downward. It is to be noted, that with the two highest points of the success curve correspond the two highest points of the time curve, and with the lowest point of the success curve corresponds the lowest point of the time curve. These results militate against any general statement of the relation of the success and time curves as one of inverse variance. Our average time is somewhat longer than that obtained by Müller and

[1] *Loc. cit.*, S. 266.

Pilzecker. This appears partially explicable in that in the present experiment the average percentage of successful syllables was fairly low. The number of repetitions was restricted lest the subject should too often get all the response syllables correct. This would have a tendency to give comparatively long times. That the explanation is adequate for the full difference, can scarcely be affirmed or denied.

Constructing a table showing the average time under each abscissa at the end of each cycle we have Table XI.

TABLE XI

Work	0	1	2	3	4	5	6
Cycle 1....	7172	3393	3782	3816	5431	8460	3867
	6	*1*	*2*	*3*	*5*	*7*	*4*
Cycle 2....	5216	4108	5998	4945	6594	6518	4629
	4	*1*	*5*	*3*	*7*	*6*	*2*
Cycle 3....	5866	5502	5400	5633	6328	6518	4402
	5	*3*	*2*	*4*	*6*	*7*	*1*
Cycle 4....	6451	6544	6381	5786	5570	6557	4740
	5	*6*	*4*	*3*	*2*	*7*	*1*
Cycle 5....	7039	6756	5625	6548	5967	7773	5706
	6	*5*	*1*	*4*	*3*	*7*	*2*

The italicized figures represent the order of the length of time of the particular abscissa in the particular group. It is noticeable that abscissa five maintained the highest position throughout save at the end of the second cycle, when it occupied the sixth. Abscissa 6 twice occupied the first position, and never above the fourth. Abscissa 0 twice occupied the sixth position, and never below the fourth. Abscissa 3 seemed to hold a median position throughout.

Eleven per cent of the total successes possess the characteristic of having been given erroneously as responses to test syllables, previously to their being given in the correct position. These responses, when appearing in the correct position, usually elicited long times, the average time being 10934σ. It is very probable that this long average time arose from the inhibitive influence occasioned by having given the syllable in response to a previous test syllable.

It might be suggested that the long average time was due to some few very long unnatural times, due to chance occurrences. In order to throw light upon this point a table is

presented showing the distribution of the responses according to their time length.

TABLE XII

Work	0	1	2	3	4	5	6
$T < 1000$	1	1				1	
$1000 < T < 2000$	13	9	12	6	16	9	8
$2000 < T < 3000$	8	9	6	11	4	12	11
$3000 < T < 4000$	11	3	9	5	5	4	7
$4000 < T < 5000$	1	3	5	3	6	4	3
$5000 < T < 6000$	3	1	3	5	3	1	1
$6000 < T < 7000$	2	2		3	2	3	2
$7000 < T < 8000$		3		4	2	1	2
$8000 < T < 9000$		1	2	1	1	2	2
$9000 < T < 10000$	1	1	2	1	2		3
$10000 < T < 11000$			1		1		
$11000 < T < 12000$	1	2	1		1		
$12000 < T < 13000$	1			2			
$13000 < T < 14000$	1	1			1	3	1
$14000 < T < 15000$	2	1	1	3	1	1	
$15000 < T < 20000$	1	2	2	2	3	3	1
$20000 < T < 30000$	5	3	1	2	2	4	1
$30000 < T < 40000$	1					2	1

The arrangement is self-explanatory. The number of long times is rather large, except in case of abscissae 6 and 2, to be disregarded on the basis of unnaturalness. Abscissae 6 and 2, if considered in isolation, may appear to give weight to this idea. To be sure, for adequate comparison of the numbers under different abscissae, the total number for each point should be the same. However, the difference is slight, and if we correct the table to a standard of 50 as a total, proportionately to the present distribution, the correcting figure would in no case exceed 2, usually, not approaching 2 save in one or two cases under each abscissa. Bearing this correction in mind, we note that for $T < 2000\sigma$ the order of the abscissae, according to brevity of time, is 4, 0, 2, 1, 5, 6, 3. For $T < 3000\sigma$, this order is 1, 6, 5, 0, $\left\{\begin{matrix}2\\4,\end{matrix}\right.$ 3. $T < 4000\sigma$, 0, 6, 2, 1, 5, 4, 3. $T < 5000\sigma$, 2, 6, 0, 4, 5, 1, 3.

Plotting a curve for all those times less than 4000σ and another curve for all those times less than 3000σ we obtain the following, Figs. 6 and 7:

The curves fluctuate about the horizontal. This fluctuation is exceedingly slight. The maximum difference obtainable between two points in the curve of Figs. 6 is 283σ, in the curve

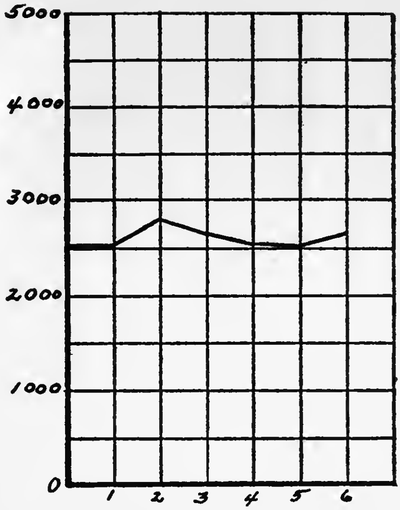


FIG. 6

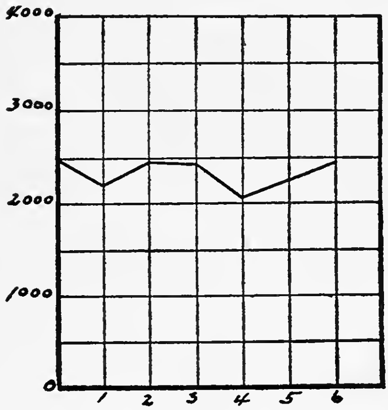


FIG. 7

of Fig. 7, 406σ. According to the general conception of retroactive inhibition, the present time curves, as well as the general time curve, should gradually rise as the abscissae increase. We find no such tendency unquestionably manifesting itself. The curve of Fig. 6 ends at abscissa 6, 134σ higher than its starting point. The curve of Fig. 7 ends 20σ lower than its starting point.

Z. B. was experienced in learning nonsense syllables. It can

not be said that her learning of them was free from sense associations, yet she was not given to consistently forming them as an aid in remembering the syllables. Occasionally it was noticed that an associated (sense) syllable gave quite a long reaction time. In such cases the mental process seemed to be something like this: The subject recalled that in the learning there was a sense association connected with the test syllable but, somehow, it had dropped out, and time was consumed in search for the sense association. Sometimes the mere fact of an established sense association would lead to an incorrect response. The association would work but, due to its sense relation, might give some word that would fit the association just as well. In a few instances it was noted that sense associations, established during learning, did not consciously work for the recall, even though the correct response was given. Whether the sense association worked as a subliminal mediate association, or whether the pure association was strong enough to recall the correct response, cannot be definitely stated.

The subject thought she noticed variation in the different series of syllables with respect to the difficulty of learning them, characterizing some as hard and some as comparatively easy.

The subject was repeatedly questioned relative to any noticeable influence of the interpolated work upon the learned syllables. Characteristic responses are, "Noticed no influence of the work," "Didn't notice influence of work." Sometimes the subject would be surprised at the result at the end of the test, having expected to give a greater (or less) number of correct responses.

In cases when most, or a very few, of the responses were correct, the subject was questioned for any apparent reason for such a result. None was apparent. In the only case where all the responses were correctly given, W. 0, R. 15, the subject characterized the result as a "Happy accident."

There were comparatively few recurrences of measures in the variant interval, an average of about one for every two series learned. The majority of these occurred during the variant

interval R. 15, or in the rest period previous to any work engaged in. As many recurred with R. 15 as recurred in the first rest interval of all the other five positions, where work followed a short rest period. About one-third of the recurrences came in the rest period following work. Only two measures and one isolated syllable are reported as having recurred during the work period. The measures reported as recurring almost invariably gave rise to correct responses in the test. Three instances are recorded to the contrary. These three recurred in the rest period following work. It may be said that there is slight evidence in favor of the view that the advantage shown by the R. type over the W. 6, R. 9 type was not due to the retroactive effect, in the latter case, but due to cutting off a few additional repetitions of some of the measures by the work introduced, while in the former case, a few additional repetitions went on unhindered. A consciousness of any such tendency towards a continuance of the repetition of the syllables, immediately after the learning process, was denied by the subject. In fact, the subject's opinion was that the syllables became a kind of nonentity during the rest period, the syllables, *per se,* not having any thing particularly attractive about them, tended to drop out of mind, while necessarily the mind wandered into easy channels of thought.

The number of successful responses for the first and seventh positions was, for R. 0, W. 6, 9 and 6 respectively; for R. 6, W. 0, 5 and 13. This appears slightly in favor of the view just referred to. When the remaining experiments, subsequent as well as foregoing, are considered in this respect, the seventh position usually has a tendency to give a few more results with rest than with work immediately following the learning. This tendency, however, is not sufficiently great to point to the interference by the work with additional subliminal repetitions as being more than a secondary factor, or otherwise as one of several primary factors, in explaining the difference at hand.

Experiment IX (b)

This experiment is a combination of Experiment IX (a), with the same subject. Two variations, however, are introduced; one with respect to the variant interval, the other with respect to the kind of work used in the variant interval. The subject either rested the whole of the variant interval, or she worked six minutes and rested nine minutes before testing. The work, in the latter case, came immediately after the learning of a series. The comparison series was learned and tested after fifteen minutes rest. On one day the series with work following was learned and tested first, on the next day the comparison series was given the first place. Cross-multiplication was no longer used as mental activity for producing the retroactive effect upon a learned series. For the work, or mental activity, the subject was given a problem to solve. Such problems were used as one would class as of the recreation type. A new problem was given each day.

The experiment continued eight experiment days, with the following results, Table XIII, $n = 56$:

TABLE XIII

	S_3	r	m.v.	%	S_2	S_1	T_r	$T < 2000\sigma$	$T < 1500\sigma$
Cs. I. Rest 15	30	3.67	1.5	53.6	3	3	5238	11	5
Cs. II. Work 6, Rest 9..	26	3.25	.94	46.4	2	4	5593	4	0

We again note a slight advantage in favor of R. 15. With the greater number of successful responses is correlated a shorter average reaction time. With the exception of the greater m. v. for Case I, the results point towards a slightly injurious effect of the mental activity following the learning of a series.

If we consider the first four experiment days, the number of successes for Case I and for Case II are 17 and 13 respectively. For the last four experiment days the corresponding figures are 13 and 13, thereby indicating that the whole disadvantage of Case II appeared in the first group of four experiment days, and was not equally distributed throughout the whole eight days.

Table XIV is presented for further considerations.

TABLE XIV

A Series

D	W	R	D--	Di-	-i-	-it	--t	D-t	S_3	S_2	S_1
1	6	9		1					4	1	
2	0	15		1					5	1	
3	6	9			2				1		2
4	0	15							6		
5	6	9			1				4		1
6	0	15			1				2		1
7	6	9							3		
8	0	15				1			6	1	
				2	4	1			31	3	4

B Series

D	W	R	D--	Di-	-i-	-it	--t	D-t	S_3	S_2	S_1
1	0	15							3		
2	6	9		1					4	1	
3	0	15			2				3		2
4	6	9							4		
5	0	15							1		
6	6	9			1				2		1
7	0	15		1					4	1	
8	6	9	1						4		1
			1	2	3				25	2	4

Comment upon this table is scarcely necessary, since it conforms with the results shown in Table X. Consequently, the discussion presented in connection with Table X is applicable to the present table.

If we now combine the present results with those of Experiment IX (a), we greatly increase the comparative figures for the two cases, viz., (1) learning, rest fifteen minutes, test and (2) learning, work six minutes, rest nine minutes, test. We thereby obtain comparative results for the two cases when n = 196. The different magnitudes appear in Table XV.

TABLE XV

	S_3	%	Tr
Cs. I. Rest 15	88	55.7	6382
Cs. II. Work 6, Rest 9	70	44.3	5667

In five of the seven cycles, four results each, of the combined results, the number of successes for R. 15 slightly exceeds that for R. 0, W. 6, R. 9.

From the introspective side little can be added. The subject reported that she did not notice any inhibitive effect of the mental activity engaged in after learning a series. She was of the opinion that the new kind of material used for mental

activity did not noticeably command her attention more than the cross-multiplication.

Experiment X

The general plan of this experiment was the same as that of Experiment IX; ten repetitions were used. There intervened between the learning and the test of each series of syllables fifteen minutes, the last nine of which were always spent as a rest period. In the first six minutes cross-multiplication, as interpolated work, was introduced, the amount varying with the cyclic order as already outlined. Two series were learned on each experiment day.

After one and one-half cycles the subject, A., could spare no more time for the work. The experiment closed with n = 42, or six tests for each point of the six minutes varied. The results are presented below in Table XVI:

TABLE XVI

	S_3	Tr
Rest 0, work 6, rest 9	15	1249
" 1, " 5, " 9	17	2196
" 2, " 4, " 9	19	1762
" 3, " 3, " 9	18	2451
" 4, " 2, " 9	23	1762
" 5, " 1, " 9	12	1689
" 6, " 0, " 9	14	2500

The first column contains the disposition of the variant interval. Corresponding to this, the second column contains the total number of successes, and the third column contains the average time for the correct responses.

The experiment was not carried to sufficient length to permit of great stress upon the results obtained. However, it seems apparent that there is no trace of a tendency towards the appearance of retroactive inhibition. In fact, we should infer that a modicum of work aids in producing a large number of successes. A peculiar departure exists in that with the most (least) work the average time appears the shortest (longest).

It should be mentioned that A. could scarcely avoid sense associations to connect the two syllables of a measure. Indeed, it was the exception, rather than the general rule, for him to

get a correct response that had no sense connection with its paired syllable.

Experiment XI

P. served as subject for the present experiment. The general plan is the same as that of Experiment III; eight repetitions were used. The length of the variant interval was fifteen minutes. A comparison was planned between only two conditions, between results obtained when no work was used in the variant interval, and those obtained when the variant interval was thus disposed: Immediately after learning, ten minutes work, followed by five minutes rest. The work used was playing chess. The operator had the chess-men in position previous to the learning of a set of syllables, that were to be followed by work, so that the play might begin without delay. Two sets of syllables were learned and tested on each experiment day. At least five minutes intervened between the close of the test of the first set and the beginning of the learning of the second set. On one day the experiment began with the work type, on the next day with the rest type. The experiment continued ten experiment days with the following results, Table XVII, n = 70:

TABLE XVII

	S_3	r	m.v.	%	S_2	S_1	T_r	$T<1500\sigma$
Cs. I. Rest 15	28	2.8	1.44	40	9	11	2343	14
Cs. II. Chess 10; Rest 5	35	3.5	1.10	50	9	6	2392	10

In the light of the explanation of the previous tables, the symbols used above require no further explanation.

Here extraordinary results appear overbalancing the scale in favor of Case II. The m. v. of Case II is slightly less than that of Case I. The average time of the successful responses is 49σ longer for Case II than for Case I. Case II is slightly favored in the number of successes giving time less than 1500σ.

In the present experiment the time factor gives—and then very meagrely—the only possible indication of the deleterious influence of retroactive inhibition. The number of successes—unquestionably the deciding criterion—instead of lending weight to such an influence of retroactive inhibition, distinctly nullifies

its possibility. In the opinion of the writer, the advantage shown by Case II is not to be interpreted as showing that the procedure of Case II is the more productive of successes in general. It seems that this advantage finds sufficient explanation in terms of chance variation in the syllables, experimental method, etc.

Relatively to the work used, it may be remarked that there occurs to the writer no mental employment that holds the attention more slavishly than does the game of chess.

Experiment XII

It will be remembered that in all of our previous experiments only experienced subjects were used. From a consideration of the possibility that subjects, inexperienced in learning nonsense syllables, might show quite different results from those shown by experienced subjects, the present experiment consisted in carrying out the previously adopted general plan with 34—11 women, 23 men—laboratory students, inexperienced in learning nonsense syllables. Each subject served two experiment days. Two tests were given him on each experiment day. Seven-measure syllables, two syllables to the measure, were given twelve repetitions for each subject. The variant interval—fifteen minutes—found distribution into two types, a rest (R.) type, consisting in rest throughout the variant interval; and a work (W.) type, consisting in working six minutes immediately following the learning of a set of syllables, then resting the remaining nine minutes of the variant interval. The work used was three problems of the recreation type.

The subjects were informed concerning the experiment only sufficiently to enable them to carry out their part of the experiment. At no time was it hinted that the operator's problem dealt with retroactive inhibition, or the comparison of results following work and rest. Several had the idea that some test of their memory was being made. The subject did not know, until the end of the learning process, whether he was to work or rest. The operator informed him at the beginning that he (the operator) would give him a signal, either "Work" or "Rest." In the case of "Rest" being given, he was to abstain

from any particular mental thought; in case of "Work," he should turn over the previously prepared sheet of problems, select one of the three and work hard until the signal for stopping was given. The sheet of paper, containing the three problems written on one side and the title "Problems" written on the other, was placed, with the written problems down, in easy reach of the subject. A sheet containing three problems different from those used the first experiment day was used for the second experiment day.

The two experiment days of each subject were separated by no constant time interval. It was considered necessary for each subject to maintain the same hour of the day in his two experiment days. This was departed from in only three instances, and then the displacement was only one hour.

In order to maintain an equal footing for each of the two types (R. and W.), seventeen of the subjects began their first experiment day with the R. type; and seventeen with the W. type. Those beginning the first day with the R. (W.) type began the second day with the W (R.) type.

The results obtained are abridged in Tables XVIII (a), XVIII (b), and XVIII (c) following:

TABLE XVIII (a)

		Type R				Type W			
	D.	S_1	S_2	S_3	T_r	S_1	S_2	S_3	T_r
No. 1	W		5	7	1848	1	2	7	3175
2	R		1	10	2432			6	2317
3	R	1		5	2739	1		6	7739
4	R	1	3	6	1180	2		5	1099
5	W		1	9	1285	4	2	6	1830
6	W	1		6	4939	1		7	2173
7	R	1	1	5	2818	1	1	6	1380
8	R		2	12	1856		2	10	1747
9	R	2	2	5	1059			5	4308
10	R		1	9	1397	1		8	1317
11	R	3	2	5	1873	1	1	10	1806
T. G. A.		9	18	79	2120	12	8	76	2232

TABLE XVIII (b)

	D.	Type R S₁	Type R S₂	Type R S₃	Type R Tr	Type W S₁	Type W S₂	Type W S₃	Type W Tr
		S_1	S_2	S_3	T_r	S_1	S_2	S_3	T_r
No. 1	R	1	2	8	1231	2	1	7	1086
2	W	1		6	0830	1		6	0916
3	R	1	2	3	0906	2	2	1	?
4	W			10	2993		2	10	1348
5	W		2	5	2329			5	2707
6	W		1	6	2670	2	1	4	1968
7	W	2	1	5	0742			7	1326
8	W	1		10	1680	1		7	1502
9	W	2	3	6	1636		3	6	1849
10	R	3	1	2	?	2	1	2	4922
11	W	2	3		?	2	2	2	1737
12	R	2	1	3	1187	2	1	2	?
13	W		1	3	1922		1	6	1102
14	R	1	1	6	2620		2	4	10471
15	W	2		4	0787	3	1	5	1057
16	R		1	5	1377		3	4	0862
17	R	3		1	3948				
18	R	1	1	8	2689		2	10	1644
19	W	1	3	6	2546			11	2156
20	R	1	1	4	1710	2	1	3	4697
21	W	1	2	5	1332			10	1433
22	W	1	1	6	1587	2	1	6	1764
23	W		1	11	3062	1	5	6	1700
T. G. A.		26	28	123	2002	22	29	124	1969

TABLE XVIII (c)

	Type R.				Type W.			
	S_1	S_2	S_3	T_r	S_1	S_2	S_3	T_r
Comb. T. G. A.	35	46	202	2047	32	37	200	2184

Table XVIII (a) shows the results for the eleven women. Table XVIII (b) gives the results for the twenty-three men. In the column D. is to be found the type—whether R. (rest) or W. (work)—beginning the first experiment day. T. G. A. = Totals and General Average, the latter referring to the time only. In Table XVIII (c) the results of Tables XVIII (a) and XVIII (b) are briefly combined. Under T^r is found the average time, obtained by totalling the times for the successful responses for the R. (or W.) type and dividing by the number of successful responses.

It is obvious that the results of any particular subject, considered alone, are of little value. However, when the results of the different experiments are considered in relation to each other, or *in toto,* it may be possible to approach some general conclusion. We reverse the order and deal with the latter first.

First. The total number of successes for the R. type was

202, that for the W. type was 200. There exists a difference, wholly insignificant. The average time shows a slight increase—137σ—in type W. over that of type R. If we glance at the time results of XVIII (b) we note that No. 14 apparently gives a "freak" result, with respect to the W. type, in that it is so far different from any other average obtained. If we neglect the results of No. 14, our average, *in toto,* for the R. type is 2629σ, and for the W. type, 1983σ. This modified form appears more nearly correct, otherwise one result, decidedly outside the limit of variation, would exert too great a determining influence upon our comparative averages. It appears then that we may say, from the standpoint of the results considered *in toto,* neither the number of successes nor the average time is indicative of any deleterious influence of retroactive inhibition.

Secondly. If we consider the different results in relation to each other, we find the following. Of the thirty-four subjects there are fourteen, each of whom gives more successes for the R. type than for the W. type. There are twelve, each of whom gives more successes for the W. type than for the R. type. Eight of the thirty-four are neutral. This seems adequate proof that there is no general tendency towards favoring either type. Further, with respect to time, sixteen of the thirty-four subjects, give their average time for the W. type less than that for their R. type. Thirteen of the thirty-four subjects give their average time for the W. type longer than that for the R. type. Five of the thirty-four are unable to be compared. These facts of time make more certain the correctness of our modification introduced in the preceding paragraph. Again, we may say, when the results are considered in relation to each other, that neither the number of subjects favoring the R. type over the W. type, nor the number giving shorter times for their successful responses with the R. type than with the W. type, is indicative of any deleterious effect of retroactive inhibition.

Experiment XIII

The present experiment is a departure from the previous experiments, both as to method and as to apparatus. We may

designate the method as of the Reconstruction type. The apparatus consisted of a chess-board, five distinct chess-men (a pawn, a knight, a bishop, a rook, and a queen), a piece of cardboard 51 x 62 cm., and a stop-watch.

The chess-board was placed upon a table. The subject, Z. B., sat at one side of the table; the operator stood at the other. The operator placed five chess-men upon different squares of the chess-board, and took a record of their position. During this arrangement the piece of cardboard rested on the table, on the long side as a base, between the chess-board and the subject's eyes, preventing the subject from seeing the position of the chess-men. The cardboard was raised and the subject allowed fifteen seconds to study the different positions of the different men. After the fifteen seconds exposure, the cardboard was replaced in its previous position and the men were removed by the operator and placed in a convenient place for the subject to get. The cardboard was then laid over the face of the chess-board. The three minutes immediately following the closure of the exposing process, found disposition in two general types, a rest (R.), and a work (W.) type. The R. type consisted in the subject's doing nothing for the three minutes. The W. type consisted in the subject's working two minutes and resting one minute. For the first eight days the work consisted in the addition of columns of figures; for the last four days simple arithmetical problems were used, a new one being given each required time. Three minutes after the end of the exposure process, the cardboard was removed from the chess-board for the reconstruction, by the subject, of the previous positions occupied by the different chess-men. The time required by the subject for the reconstruction, was taken with the stop-watch. After the reconstruction the cardboard was replaced in its position between the subject and the chess-board, and the reconstructed position of the men recorded by the operator. The experiment was then repeated. At least three minutes rest was allowed the subject between the closure of the reconstruction and the beginning of the second experiment. On any experiment day six tests were

made. The R. and W. types alternated on any particular day. The first three days began with the R. type, the next three began with the W. type, the next three with the R. type, and the last three with the W. type. The experiment continued twelve experiment days, giving thirty-six tests for the R. and thirty-six tests for the W. type.

The errors in the reconstructed forms, and the time, were computed and tabulated. The error value for any chess-man, in the reconstructed form, was obtained, speaking mathematically, by adding the differences between the ordinates and the abscissae in the two cases, chess-board squares considered as units. To illustrate, a piece originally placed at b4 (German chess notation), and in the reconstruction, placed at g2, would give rise to an error value of 5 + 2 or 7 for the particular piece. The errors for the five men were totalled, and this total was considered the error value of the test.

The results of the experiment follow in Table XIX:

TABLE XIX

		R. Type		W. Type	
		E.	T.	E.	T.
1	R	31	265	38	192
2	R	13	135	54	232
3	R	33	220	26	197
4	W	29	209	24	117
5	W	34	146	38	259
6	W	59	142	44	169
7	R	43	294	20	152
8	R	24	92	27	102
9	R	36	204	41	150
10	W	29	174	28	194
11	W	18	191	41	209
12	W	24	151	41	279
Totals		373	2223	422	2252
Av.		10.4	67.4	11.7	66.2
M.v.		5.6		6.0	

The first column gives the number of the experiment day and the type of test with which the work began on that day. Under R. Type and W. Type are given the errors, in sub-column E., and time, under sub-column T.; the figures given represent the total of the three tests of similar type for the experiment day opposite which the particular figures appear.

The difference between the averages for the two cases is so

small as to be wholly non-significant, while the m. v. is non-indicative.

In the reconstruction here required of the subject, we are dealing not merely with the impressibility aspect, but with the subject's ability to hold in mind an ordered system. This retention of systematic order is doubtless one of man's last acquirements in his mental evolution, and considered from the aspect of perseveration, appears to be one of the first to drop out. Consequently we might expect retroactive inhibition, assuming its existence, so much the more to manifest itself when dealing with this apparently unstable mental phenomenon. From the results at hand such, however, is not the case.

G. GENERAL DISCUSSION

In dealing with the individual experiments we have partially discussed the results obtained. A systematic unification remains to be accomplished.

Knowing the conditions set by an experimenter, his results place all who care to consider them upon a fairly equal basis. The domain of results gives way to that of interpretation, from which standpoint divergent lines may be taken by different interpreters. It is in this field of interpretation that the scientist, though in a sense "driven by the facts", in another sense, "moulds his own laws and makes his own conclusions."

To the writer it seems unquestionable, from the results presented in this paper, that too much stress has hitherto been laid upon the effect of retroactive inhibition. That there is such a thing as retroactive inhibition we are not wholly prepared to deny. Our results seem to justify the statement—and this is our main THESIS—*That retroactive inhibition plays a significant part in influencing the recall of nonsense syllables, appears exceedingly doubtful.* The tentativeness of our position follows necessarily from the considerations already presented. Exhaustive experiments are necessary before generalities can be indulged in if, indeed, generalities are ever permissible in dealing with mental phenomena.

It may be suggested that our results, and consequent con-

clusions, conflict with the accepted view of the working of the Perseveration Tendency, which, indeed, is one of the essential units upon which the theoretical argument for the existence and explanation of retroactive inhibition is based. Müller and Pilzecker appear to have thought of the nature of the perseveration tendency as a kind of after-discharge—a continued activity—of the nerve elements following any learning activity. The physiological work of Sherrington[1] on the spinal cord and the work on inhibition by Shepard[2] indicate that the after-discharge of nerve elements is definitely inhibited by any neural activity taking place during this after-discharge. From the standpoint of the greater value of divided repetitions as compared with accumulated repetitions the perseveration tendency as such seems definitely established. Our results leave retroactive inhibition questionable. The logical consequence, then, is that the nature of the perseveration tendency, which leads to the setting of associations, is not that of an after-discharge.

Again, it seems that hitherto emphasis has been laid upon retroactive inhibition as an inhibition presenting a single aspect—and that inhibitory. The work of both Sherrington and Shepard seems to indicate that inhibition is not a single-phased process. According to these investigators two processes giving rise to inhibition mutually inhibit each other; neither can inhibit the other without itself being subject to inhibition. If retroactive inhibition is to be conceived as according with this idea of the double aspect of inhibition in general, then we should expect the learning of a Hauptreihe to inhibit the learning of a Nachreihe as well as the learning of a Nachreihe to inhibit the preceding Hauptreihe. Consequently, against the conception of retroactive inhibition as of a single aspect—and this is probably the conception of Müller and Pilzecker—there may be urged two arguments, (1) the difficulty of the conception of a one-sided inhibition, and (2) the results of the present work, which do not necessarily require the assumption of retroactive inhibition at all.

[1] *The Integrative Action of the Nervous System,* 1906.
[2] *Psychological Review,* Vol. XX, No. 4, July, 1913.

We have tended to ascribe most of the differences between the comparison and the main series to chance variation. It may be claimed—and rightly—that chance variation should give evidence against as often as for retroactive inhibition. Considering our experiments in their totality, the majority of them *slightly* favor a trace of retroactive inhibition. Whether this tendency of the majority is itself a variation further experiments may decide. At present, in the opinion of the writer, the validity of retroactive inhibition remains more or less questionable. If we assume a slight amount of retroactive inhibition it may still be explained as due to a tendency of the work to block the after-discharge of the just learned syllables. The nature of this blocking is a difficult question.

For the small amount of retroactive inhibition granted I may be permitted to suggest an explanation analagous to that existing for the transference of training. From the neurological standpoint, in the learning of a series of syllables, we may assume that a certain group of synapses, nerve cells, nerve paths, centres, etc., are involved. Immediately after the learning process the after-discharge continues for a short time, tending to set the associations between the just learned syllables. Any mental activity engaged in during this after-discharge, involving or partially involving the same neurological group, tends, more or less, to block the after-discharge, and gives rise to retroactive inhibition. Engagement in any mental activity, involving a new—so far as it is new—group of synapses, neurones, etc., would allow the setting process of the just excited group to proceed unhindered. The effect of retroactive inhibition would vary directly as the relative identity of the neurological groups concerned. It appears exceedingly plausible that any given group involved in learning nonsense syllables is a relatively restricted and, more or less, isolated one, scarcely involving the more intricate ramifications of the higher association paths and centres, and hence much less liable to be influenced by mental activity, involving the complexity of the higher centres and processes. Upon this view we should expect retroactive inhibition to appear more readily where material

similar to that learned is used for the interpolated work. Where the learning of nonsense syllables is followed by work of a different nature—a mathematical problem, for instance—the relative number of identical elements of the two groups may be so few, owing to the complexity of man's neurological system, that no appreciable retroactive effect is elicited.

The neurological explanation just presented seems sufficient where the deleterious effect of the work is slight but appears inadequate for the results of Müller and Pilzecker which were obtained by using additional nonsense syllables as the interpolated work. To the writer it appears that Effectual Inhibition, occasioned by merely increasing the number of syllables, may play the *decisive* part in lessening the percentage of successful responses in the recall of a Hauptreihe which has been followed by the learning of a Nachreihe. Probably in this way is to be explained the following quotation from Eleanor C. McC. Gamble's "A Study in Memorizing Various Materials by the Reconstruction Method."[1]

"With G. retroactive inhibition was obvious. Each series [*i.e.* of smells, colors, nonsense syllables] was remembered fairly well until the next was given. That is to say, the subject could name hours afterwards the members of the last series given, and the associations involved would remain almost undisturbed for weeks. But as soon as a new series was given, the eraser (the subject actually visualized a blackboard eraser in this connection) was drawn over the old series. A 'smudge' might remain to make the new series illegible but the old one could no longer be read off."

In the opinion of the writer a similar explanation applies to Ebbinghaus'[2] attribution to retroactive inhibition of the extraordinary increase in the number of repetitions necessary for memorizing lists of syllables as the "memory span" is exceeded. To quote,

"Die einzelnen Associationen beeinträchtigen und lockern sich immer wieder durch *rückwirkende Hemmung,* und die

[1] *Psychological Review,* Monograph Sup. No. 43, 1909, p. 138.

[2] *Grundzüge der Psychologie,* 1902, S. 652.

Herstellung einer bestimmten Festigkeit erfordert mithin einen immer grösseren Arbeitsaufwand zur Überwindung dieser Störung, je höher die Zahl der hemmenden und gehemmten Glieder sich beläuft."

But, in the light of the present experiments, the writer does not feel disposed towards accepting, as a general conclusion, even a greater difference when a consideration of pictures is substituted for the Nachreihe. There seems little doubt that cross-multiplication involves the expenditure of at least as much—and very likely more—mental energy as the contemplation of landscape pictures. With the use of such work the only one of our experiments particularly favoring the results of Müller and Pilzecker is Experiment III, and in that experiment the results are much less "striking" than those obtained by Müller and Pilzecker. The same subject, however, in Experiment I gave the two lowest points (of 16 points) of the success curve with R. 15, W. 0, and in Experiment IV gave even more successes with R. 2, W. 13 than with R. 15, W. 0, though this latter point can have no particular weight against the results of Müller and Pilzecker, since their work with pictures extended no farther than two minutes after learning.

It might be argued that retroactive inhibition, expending its effect upon the rapidly descending part of the forgetting curve (as given by Ebbinghaus[1]) may influence the relative number of successes relatively more after a lapse of eight minutes than after a lapse of fifteen minutes, thereby partially harmonizing our results with nonsense syllables with those of Müller and Pilzecker. Admitting the validity of some such argument, it appears extremely insufficient to explain the differences obtained. Even from the standpoint of reaction time we fail to agree with the German investigators. Some of our experiments harmonize with their time results, while others oppose. Seemingly, then, the only course open to us is to place the results of their Versuchreihe 35 in some such class as "Happy Accident," or question their saliency upon the basis of unnaturalness.

[1] *Über das Gedächtniss,* 1885, p. 203.

It can scarcely be maintained or denied that a subject's tendency or non-tendency towards the formation of sense associations is a determinant of the appearance or non-appearance of results indicative of retroactive inhibition. Subject B., whose tendency in this respect was marked in the preliminary experiments, though not particularly noticeable in the present work, is the only one giving fairly unquestionable results in favor of retroactive inhibition, and from the introspective side, it will be remembered, this subject stated that work had no influence: if he had a syllable, he had it. This, to be sure, had no significance further than that the subject noticed no particular influence of the work. Subject A. of Experiment X, whose tendency towards the formation of sense connections between the syllables was well known previous to the experiment, and appeared throughout the experiment, gave results inharmonious with the assumed deleterious effect of retroactive inhibition. Our other subjects, it may be said, had no particular tendency in this respect, and not one of these gave results unquestionably in favor of the existence of retroactive inhibition. Argumentatively, from one standpoint at least, if retroactive inhibition is general in its effect, it would seem that of the two classes of subjects, those subjects possessing no particular tendency towards sense associations should show greater evidence of the presence of retroactive inhibition.

Doubtless it will have been noticed that the discussion has almost wholly neglected the results of Experiment VIII. As was mentioned previously, the fatigue element complicates these results and forbids their consideration in favor of retroactive inhibition.

Professor Pillsbury has indicated[1] the analogy between retroactive inhibition and the retrograde annesia of the psychiatrist. In the case of the strong blow or emotional shock, it may be assumed that the effect is a general one and that the bonds, connecting the neurological groups, acting at the time with the remaining neurological groups, are severed. The events represented by this now isolated group are *forgotten* in the

[1] *Essentials of Psychology*, 1913, p. 196.

sense that they are not easily reached from the remaining neurological groups. That they are not wholly lost to the individual is shown by the fact that they may later return to consciousness, or, under suitable conditions, be reached. Interpolated work, it may be said, does not tend towards any such isolation of a group which has just been excited. Consequently, the fact that our results are not similar to those obtained by the psychiatrist, does not necessarily argue against their validity.

The number of partial responses is so small that we make no attempt to draw, from their distribution, any conclusion with respect to retroactive inhibition. We may mention that the average time for syllables, two letters correct, is much longer than that for wholly successful responses, and the average time for syllables, one letter correct, is still longer. Comparative results of a single experiment, Experiment IX (a), will suffice to show this difference, Table XX:

TABLE XX

Work	0	1	2	3	4	5	6
S_3	7039(52)	6756(42)	5625(45)	6548(48)	5967(50)	7773(50)	5706(43)
S_2	11982(8)	15994(5)	8843(11)	13596(15)	14951(7)	10033(11)	8596(10)
S_1	19610(11)	19480(9)	22849(10)	23044(12)	17684(10)	21981(14)	17406(15)

The parenthesized figures represent the number of responses for which the adjacent figures are the average time.

H. SUMMARY AND CONCLUSIONS

The present work grew out of experiments conducted by Müller and Pilzecker, whose results showed decided evidence in favor of the deleterious influence, upon learned nonsense syllables, of learning a second series of syllables, or of observing and picturing to the operator landscape pictures immediately after the learning of the first series of syllables. Their experiment with pictures as interpolated work, showed slightly more decided results in favor of retroactive inhibition than did the experiments with a second series of syllables for the interpolated work.

Our work embraces a series of thirteen experiments, extending over a period of two school years and one summer.

The apparatus consisted of a modified form of the Wirth card-exposure apparatus, Hipp chronoscope, and subsidiary apparatus. In Experiment XIII a chess-board, men, and additional apparatus were used. Experiments I to XI and XIII were extended experiments with seven subjects. In Experiment XII thirty-four subjects were involved.

Series of fourteen nonsense syllables (save in Experiment XIII) were repeated in pairs a certain number of times. On each experiment day two series, an A and a B, were learned and tested, an interval of at least five minutes intervening between the work with the two series. The purpose of the experiments was a comparison between syllables learned with no interpolated work following, and syllables learned with work—usually cross-multiplication—variously distributed within the interval immediately following the learning process. The order of the syllables was changed, and after a definite interval, the first syllable of each measure was tested for the associated syllable. The response, reaction time, and introspections of the subject, were recorded. Experiment XIII approached the problem from the standpoint of reconstruction of positions of chess-men, where the studying, by the subject, of such positions was followed in one case by work, in another, by rest.

Experiment III is the only experiment giving results characteristically favoring the assumption of retroactive inhibition. The other experiments—Experiment VIII excepted—including our most extended one—Experiment IX—do not particularly speak for the existence of retroactive inhibition, either with respect to the number of successes, or the reaction time of the successful responses. Experiment XII, upon two counts, adds decided weight in favor of the non-existence of retroactive inhibition. Experiment XI militates decidedly against the assumption of retroactive inhibition. Hence we must needs suggest that the influence of retroactive inhibition is fairly unimportant and has been given too great prominence among psychological principles.

We may suggest the following conclusions as indicated, if not wholly proven, by the results of our experiments:

1. That retroactive inhibition plays a significant part in influencing the recall of nonsense syllables, either from the standpoint of the number of successes, or the length of the reaction time, or both, appears exceedingly doubtful.

2. No positive introspective evidence appeared in favor of retroactive inhibition.

3. With inexperienced subjects no evidence appeared in favor of retroactive inhibition, either from a combination of their results, or from a consideration of their comparative results.

4. A neurological explanation of a slight amount of retroactive inhibition is tentatively offered; Retroactive inhibition may present itself where relatively identical or partially identical groups of nerve centres, neurones, synapses, etc., are involved in learning the series of syllables and in the interpolated mental activity. As the neurone groups have relatively less and less in common, retroactive inhibition may manifest itself less and less.

5. From the standpoint of the position occupied in the learning, the seventh and first measures usually gave the largest number of successful responses.

6. The B series of syllables possessed a slight disadvantage as compared with the A series, probably due to a slight fatigue effect occasioned by the A series.

7. Different subjects showed no marked individual differences with respect to the manifestation of the effect of retroactive inhibition.

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